DOCUMENT RESUME

ED 448 044 SE 064 337

AUTHOR	Boyle, Grace
TITLE	The Cookie Crumbles: A Case of Sensory Sleuthing. BrainLink: Sensory Signals.
INSTITUTION	Baylor Coll. of Medicine, Houston, TX.
SPONS AGENCY	National Institutes of Health (DHHS), Bethesda, MD.
ISBN	ISBN-1-888997-19-2
PUB DATE	1997-00-00
NOTE	169p.; Illustrated by T. Lewis. Revised by Judith Dresden and Barbara Tharp. Science notations by Nancy Moreno. For other books in the BrainLink series, see SE 064 335-338.
CONTRACT	R25-RR13454
PUB TYPE	Guides - Classroom - Teacher (052)
EDRS PRICE	MF01/PC07 Plus Postage.
DESCRIPTORS	Biology; *Brain; Content Area Reading; Elementary Education; Human Body; Mathematics Education; *Neurology; Problem Solving; *Science Activities; *Science Instruction

ABSTRACT

The BrainLink project offers educational materials focusing on current neuroscience issues with the goal of promoting a deeper understanding of how the nervous system works and why the brain makes each individual special while conveying the excitement of "doing science" among upper elementary and middle school students. Project materials engage students and their families in neuroscience issues as they learn fundamental physical and neuroscience concepts and acquire problem-solving and decision making skills. Each BrainLink unit targets a major neuroscience topic and consists of a colorful science Adventures storybook, a comprehensive Teacher's Guide to hands-on activities in science and mathematics, a Reading Link language arts supplement, and a fun and informative Explorations mini-magazine for students to use with their families at home or in the classroom. This issue offers a unique approach to learning how the senses work, including visual illusions and how the brain processes sensory information. (ASK)

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The Cookie Crumbles: A Case of Sensory Sleuthing.

BrainLink: Sensory Signals.

By Grace Boyle
Illustrated by T. Lewis
Revised by Judith Dresden and Barbara Tharp
Science notations by Nancy Moreno

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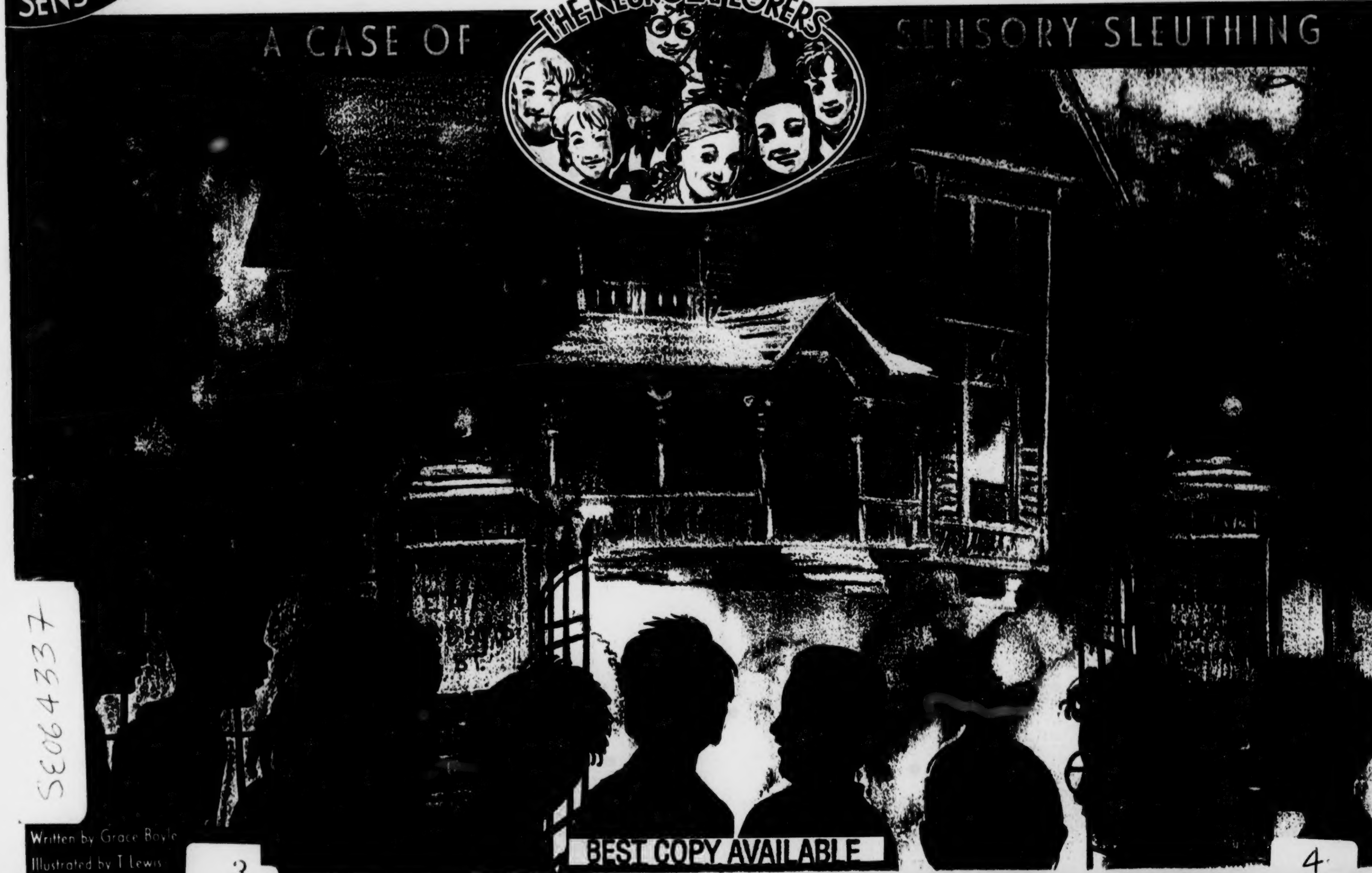
SE 1

BrainLink
SENSORY SIGNALS

THE COOKIE CRUMBLES

A CASE OF SENSORY SLEUTHING


THE NEUROEXPLORERS

SE064337

Written by Grace Boyle
Illustrated by T. Lewis

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The **BrainLink®** series for health and science education provides:

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Danger at Rocky River
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BrainLink® Adventures

THE COOKIE CRUMBLES

The NeuroExplorers™
in
A Case of Sensory Sleuthing

By
Grace Boyle

Illustrated By
T Lewis

Revised by Judith Dresden, M.S. and Barbara Tharp, M.S.

Science notations by Nancy Moreno, Ph.D.

Baylor College of Medicine

WOW!™
Publications
Houston

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Printed in the United States of America
WOW Publications, Inc.

15 14 13 12 11 10 9 8 7 6 5 4 3 2 1

ISBN 1-888997-19-2

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Development of BrainLink® educational materials was supported, in part, by funds from the National Institutes of Health, Science Education Partnership Award grant number R25 RR09833. The opinions, findings and conclusions expressed in this publication are solely those of the author and project staff and do not necessarily reflect the views of Baylor College of Medicine, the sponsoring agency or the publisher.

Design by T Lewis
Cover design by Bob Peretti
Production by Kerrie Kerns

Acknowledgments

Many dedicated professionals worked to assure the educational and scientific integrity of this publication. In particular, we are grateful to Leslie Miller, Ph.D., who initially led the project, and to Katherine Taber, Ph.D. and Karen Kabnick, Ph.D., for their contributions. Other specialists who provided guidance include: Scott Basinger, Ph.D.; Cassius Bordelon, Ph.D.; Celia Clay, M.P.H.; Dane Chetkovich, M.D., Ph.D.; Ilene Schwarz, M.Ed.; and Quentin Smith, M.S. In addition, many classroom teachers and their students provided invaluable feedback.

We also are very grateful for the continuing support of James Patrick, Ph.D., Professor and Head of the Division of Neuroscience; Stanley Appel, M.D., Professor and Chairman of Neurology; and Carlos Vallbona, M.D., Distinguished Service Professor and Chairman of Community Medicine at Baylor College of Medicine.

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The NeuroExplorers

The Beginning

All Josh Kavil saw was the stop sign. The next thing he remembered was waking up in the hospital. He had been riding his bicycle without a helmet and was struck by a car. His skull was fractured, and his brain was badly damaged.

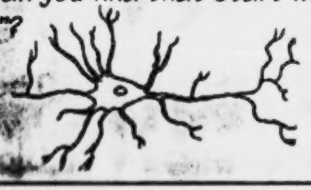
Some good came of Josh's unfortunate accident. For one thing, he learned never to ride without a helmet. Second, his misfortune was the beginning of the NeuroExplorers.

When Josh's friends came to visit him at Worthington Regional Hospital, some of them became fascinated with the field of neuroscience. On their visits, they met a neurosurgeon, a neurosurgical nurse, a neurologist and a neuroradiologist. These were medical specialists helping patients who had problems involving the brain or other parts of the nervous system.

It was Kyle Christian's idea to form the club. The members all wanted to know more about the nervous system. They also liked to solve puzzles and riddles and had an interest in investigating some of the mysteries of science.

Since they formed the club, the NeuroExplorers have volunteered at a center for the rehabilitation of brain injury patients, held a Neuro-Science Fair and spent a day in the hospital on rounds with a neurologist. They have learned a lot about how the brain and nervous system work, and they always are looking for exciting things to do with neuroscience.

Neuroscientists study the brain and the rest of the nervous system. The basic building block of the nervous system is the nerve cell, or neuron. The word "neuron" comes from the Greek word for "nerve." How many words can you find that start with "neuro-"?



The Club Members

Kyle Christian

Kyle's father is an archaeologist at Dargate University and often is away on digs. Last year, he took Kyle with him on a short dig in Belize. Kelly, Kyle's sister, sometimes does things with the NeuroExplorers, although some of the members feel that she is a little young for the club. Kyle likes to read science fiction books and play computer games. His hobby is memorizing fascinating trivia.

The Brain

When Antonio Velasquez-Ruíz, alias The Brain, was a toddler, he was very quiet and never tried to talk. One day he suddenly began speaking in complete sentences. Since then, he has been known as the smartest boy in town. The trouble is, only his best friend can understand The Brain's big words and long sentences. The Brain reads a lot, but his most-used books are a very fat dictionary, a set of encyclopedias, and Gray's Anatomy.

Max Miller

Max has been friends with The Brain since they were babies, and that's why he understands him so well. They spend most of their time together. While The Brain reads, Max often works on models of boats and planes or builds things with wood. Max became interested in neurology when his grandfather had trouble with his memory and was diagnosed with Alzheimer's disease.

Lakeisha Crawford

Lakeisha wants to be a chess grandmaster, so she carries a pocket chess game around with her. She often thinks about things in terms of chess problems, and she has developed a good memory. She also likes to play other games and sports. Karate lessons are her latest passion. Lakeisha has a little sister who has epilepsy.

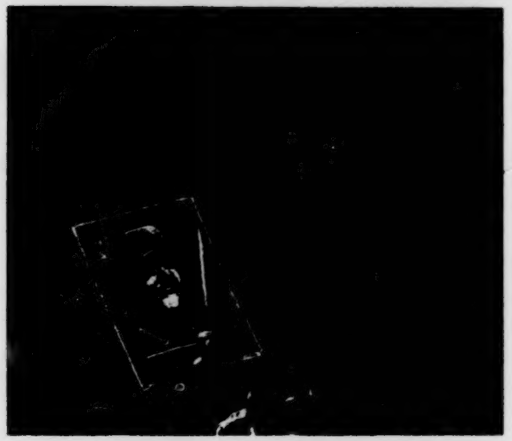
Isley I and Isley II
Identical twins, Isley I and II (even their parents don't call them by their actual first names) are always kidding each other. They both love sports and play soccer, baseball and basketball. Isley I collects baseball cards and has a 1954 Mickey Mantle in good condition. Isley II holds the record for consecutive basketball free throws in his school. Their father, a bird-watcher, got them interested in science by reading to them from the notes of Charles Darwin.

B.J. Armstrong
B.J. spends a lot of time with her drums. In fact, she carries her drumsticks with her and uses them on any hard surface she can find! She wants to play in a band, but she also wants to be a physician. B.J. has two older brothers who sometimes act as advisors to the NeuroExplorers. One brother is a neurologist at a medical school. Her brothers never liked to use her formal name, Beverly Jane, so they've always called her B.J., and so do her friends.

Shiloh Numbus
Shiloh lived on a game preserve in Africa for many years. While there, her back was injured, and now she must use a wheelchair. Before her injury, Shiloh was very athletic. Now she has become an excellent wheelchair tennis player. She also likes to put together jigsaw puzzles with thousands of pieces. Shiloh was happy to make friends with the NeuroExplorers when she came to her new school in America.

Josh Kavil
When Josh recovered from his head injuries, he couldn't wait to join the club with his friends. Josh has always liked science, because he loves to figure out how things work. He also loves animals. He has a pet lizard named Scooter, a snake named Slim, two dogs and two cats. After his experience as a patient in a rehabilitation center, he decided he would like to be a physical therapist when he grows up.

THE COOKIE CRUMBLES



A Friend Returns

Josh Kavil couldn't believe it. He looked around Kyle Christian's basement. Here he was with his friends, at last. He was glad to be back!

Kyle was tapping on the blackboard at the front of the room. "NeuroExplorers," he announced, "how about sitting down so we can start the meeting?"

"Any new mysteries?" Lakeisha asked as she made a crushing chess move against her hand-held computer.

"Guess not," Kyle said, "but it still is a very important meeting. As you see, Josh is back, and he finally is going to be an official member of our club!" Everyone yelled and clapped so much that Kyle couldn't say another word.

All the NeuroExplorers knew what had happened to their friend, Josh. He was hit by a car while riding his bicycle eight months ago. He wasn't wearing a helmet, and he hit his head when he fell. After an operation for damage to his brain, he was in the hospital for a month. He spent two more months in a rehabilitation center and then continued to go back there every day for therapy. Some of the kids had kept in touch with Josh, so he knew how they'd started the NeuroExplorers Club after his injury.

Josh held up his hands to quiet his friends. "Thanks for the greeting," he said, grinning. "Believe me, I'm happier to be here than you are to see me! And I brought some cookies for everyone, to thank you for sticking by me all this time."

"All right! Give me cookies and I'll follow you anywhere!" Isley I cried as he leaped to get the first cookie.

"Good. Maybe you'll quit following *me* around for a change," Isley II teased his brother. He grabbed a cookie for himself.

While Kyle passed the box of cookies around, Josh answered everyone's questions about his progress. The NeuroExplorers were so glad to see him, they forgot about their wish for a new mystery or adventure.

Cross-Wired

"Hold it a minute," shouted Kyle when everyone was talking to Josh at once. "Let him answer a question without interruption." The room became quiet after B.J. played a drum roll on the table top.

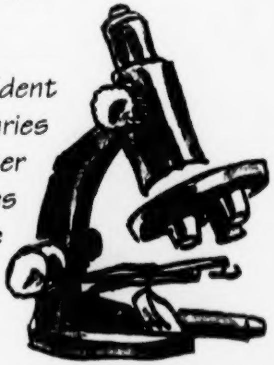
"Well, you know that I couldn't move my leg and arm at all, for a while. Boy, was that scary! But at the rehab center I learned to walk again. Look," he said, walking across the room, "I don't even need to use a cane anymore. And my right arm is working again, too!"

"Your right arm? asked B.J. "I thought you cracked the left side of your skull and hurt the *left* side of your brain. Why wasn't it your left arm and leg that wouldn't work?"

"You remember—the brain and nervous

Real-life NeuroExplorers

Today, doctors are able to help accident victims with head or spinal cord injuries in more ways than ever before. Better emergency care, improved techniques for rehabilitation and new drugs are helping to improve the recovery of people with these types of injuries.



Most nervous system pathways from the brain to the rest of the body cross over from one side of the body to the other. This happens in the brain itself or in the spinal cord. You might say that we are cross-wired! This is why damage to one side of the brain can affect movement or sensations on the other side of the body.

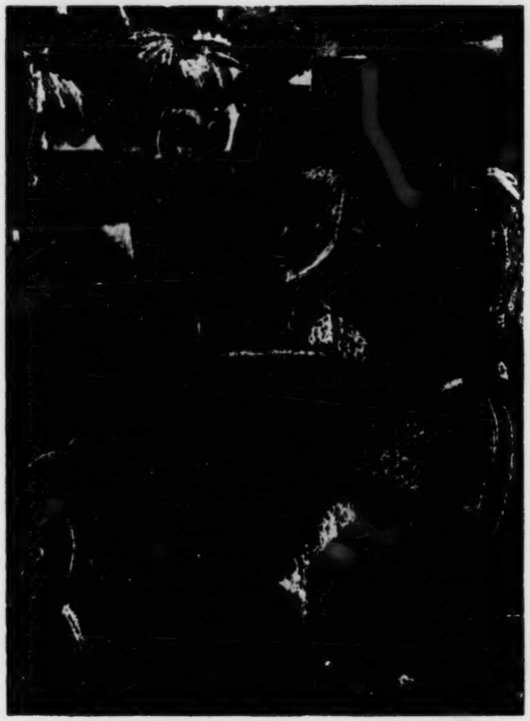
system are cross-wired," said Kyle. "Look, here's the picture of it," he added, opening a book in the pile on his shelf.

Just then, Shiloh Nimbus eased her wheelchair over to Josh and introduced herself. "Hi! I'm Shiloh," she said. "I'm a new member of the club, and I know how it feels when your body doesn't work right. I was in an accident too, but my spinal cord was injured. You're lucky your injury didn't do permanent damage."

"Yeah, I really *am* lucky to have most of the movement back," Josh said, "but I still can't hear in one ear."

Suddenly Josh stopped talking. "What's this," he said to himself, looking down into the cookie box, "a baseball card?" He blinked. Why was a baseball card lying in the bottom of the box of cookies?

Picking out the card, Josh held it up and said, "Look at this. I've got a baseball card—a Mickey Mantle rookie card from 1952."



Mystery Cookies

"Let me see that!" cried Isley I as he shoved his way to the card in Josh's hand. "Wow! Cool! That's one of the best cards there is! It must be worth a fortune at the sports card store." He held the card up, and everyone looked at it.

"It looks in perfect condition!" said Kyle.

"It looks like *mint* condition," said Isley I, the expert.

"What does that mean?" asked Shiloh.

"It means it's still in perfect condition after all these years. This is a 1952 card, and it's just like new!" Isley I explained. He pulled the card carefully out of its plastic cover and waved it in the air so all could see.

As it waved by his nose, Josh sniffed the card. "Wow, it even smells like new. You know—like a new book."

"How extremely extraordinary that an object should emit such an aroma after 40-odd years," The Brain commented.

Max turned to Josh as he explained The Brain's words for the group. "He says it's funny that a card over 40 years old smells like new."

"It's funny that an old card is in a box of cookies!" Lakeisha added. "Why do you suppose it's there?"

Josh looked puzzled. "I don't know," he said. "The box doesn't say there's a baseball card in it. It doesn't say there's any surprise. In fact, I was surprised when the cookies came to my house! A delivery truck brought the package, and it had my name on it. I don't know who sent them."

"It was nice of you to share them with us, anyway," B.J. said.

The sense of taste depends on tiny structures called taste buds located on the tongue and inside the mouth. You have over 10,000 taste buds! When you taste something, tiny receptors inside the taste buds send messages along nerves to special areas inside your brain.

Tiny taste bud inside one of the bumps on the tongue

"I thought they'd be good for a celebration, so I saved them for today," Josh answered. "It says they're from Cousin Connie's Cookie Company, but I don't know anything else about them."

"In that case, I have to tell you that this cookie isn't very good," said Lakeisha. "It's not sweet enough. I never had a cookie before that wasn't sweet."

"Mine tastes sort of like sawdust," added Max.

"I never met a cookie I didn't like, but I don't even want to finish this one," chimed in Isley II.

Tapping out a jazz beat with her feet and smashing an imaginary cymbal, B.J. spoke for the rest of them. "There def-in-ite-ly is...some-thing wrong...with these cook-ies." Smash!

The group of friends looked at each other. They almost shivered, as though an electric current had run through all of them. Kyle whispered excitedly in the sudden silence, "Why is a valuable baseball card stuck in a box of taste-less cookies? We seem to have a mystery after all!"

NeuroExplorers in Action

The club members couldn't stop thinking about the cookie mystery. Josh looked at the cookie box and found the company's address. It wasn't far away! They decided to take a field trip to Cousin Connie's Cookie Company!

The next day, they all met on a corner to take a city bus. Shiloh got on the wheelchair lift and the others climbed up the steps of the bus, excited to be on their way. At least *most* of them were. "Are you sure this bogus visit to the cookie company is prudent?" said a voice behind Kyle. It was The Brain.

"He wonders if it's smart for us to be going to this cookie company, pretending we like their cookies," Max translated.

"This is a fine time to be wondering," B.J. called out from across the aisle. "It's too late now! We're on our way."

"It's a mystery that needs solving," Kyle stated, "even if it isn't a neuroscience adventure."

"On the contrary," The Brain added thoughtfully, "it is evident that almost all human endeavor involves neuroscience. Think about it."

"He disagrees," Max said simply. "He thinks neuroscience is everywhere."

Everybody smiled. They knew that The Brain had fun being difficult. They knew he thought this trip would be a lot of fun, too—and he couldn't resist a mystery, neuroscience or not.

Cousin Connie's Cookie Company

"This is the stop you wanted, son," the bus driver announced to Kyle, "East Adams Street."

"This is it, everybody," Kyle said, leading the NeuroExplorers off the bus and waiting while the driver operated the wheelchair lift for Shiloh.

The bus's engine roared as it started off again on its journey down the winding road. "The decibel level emitted by this vehicle is sufficient to damage our auditory capacity!" shouted The Brain, covering his ears with his hands.

"He says the bus is so loud, it could really hurt your ears," Max yelled to his friends. They tried to close off their eyes, ears and noses as the bus sputtered off noisily in a cloud of smoke and oil.

Looking around to find their way, they noticed the sky beginning to darken. Rain clouds rolled in overhead. They walked down the street and stopped in front of a large gate.

"This is the address on the cookie box—410 East Adams Street," Josh announced.

"There's a sign," Kyle said, pointing to the other gatepost. "It says Cousin Connie's Cookie Company."

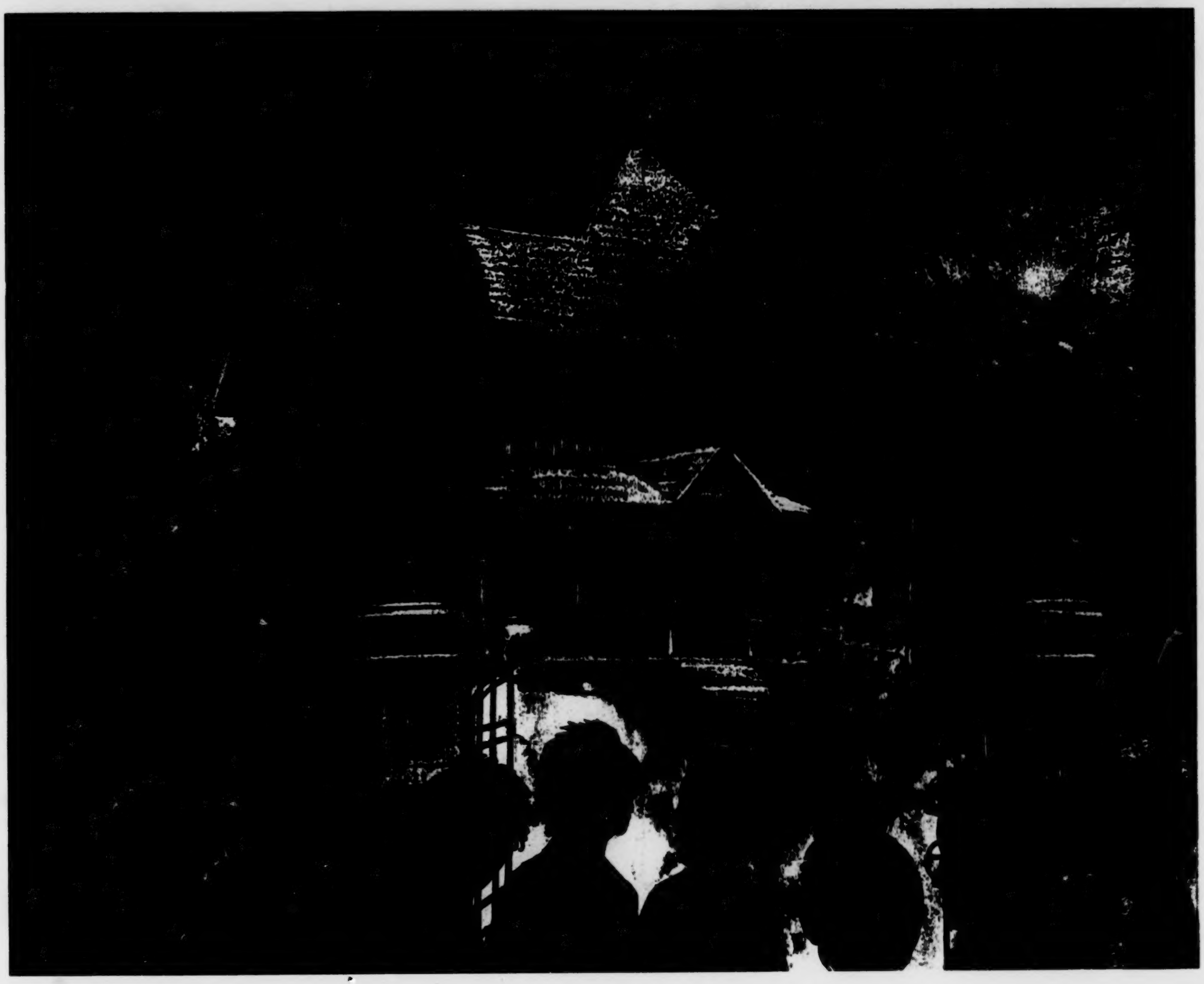
"*That's* the cookie company?" B.J. said softly.

There, just over a mound of weedy lawn, surrounded by a black iron fence and perched on a small hill was a tall, old building. It looked more like a haunted house than a bakery.

"I say we go home," Isley II said as he turned to run. His brother held him by the belt.

Loud noises can damage hearing by harming tiny hair-like cells in the innermost part of the ear. These cells convert sound waves in the air into signals that can travel along nerves to the brain.

Examples of loud sounds that can be dangerous include noises from motorcycles or trains, very loud music heard through head phones or at a rock concert, or noise from firecrackers or gun shots.



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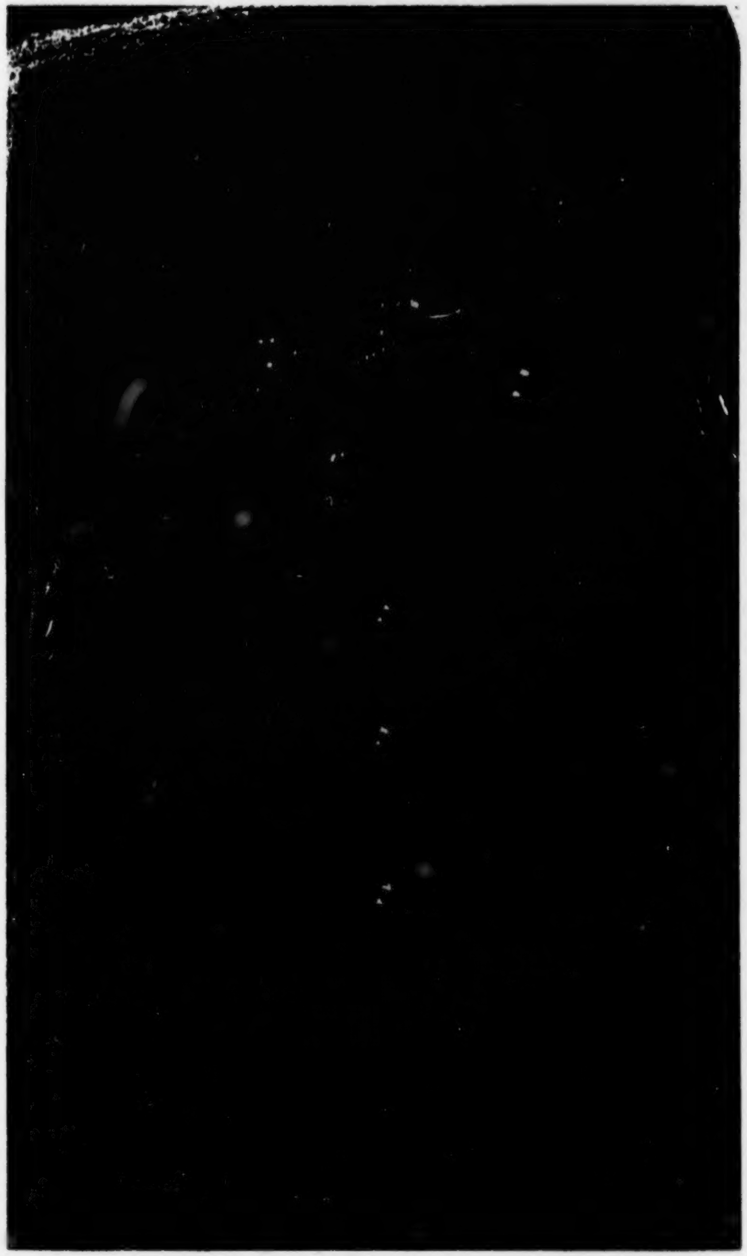
In an instant, dark clouds piled upon darker clouds until the entire sky was blotted out by threatening shadows. Rain began coming down hard.

"We have no choice now," Kyle announced. "The next bus doesn't come for half an hour. If we stand here we'll get soaked." A crashing boom and a bolt of lightning sent them hurrying toward the house.

In a pack, the club shoved through the gate and moved up the path and onto the porch of Cousin Connie's Cookie Company. Kyle and Lakeisha helped Shiloh up the worn steps. Josh boldly knocked on the door.

The door cracked open, and two eyes peered at the NeuroExplorers. Thunder boomed in the distance. The eyes squinted and pulled away, as if they were being sucked in by the darkness. Then the door swung open. A large woman loomed over them. "What is it?" she asked impatiently.



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"We're the NeuroExplorers Club," Kyle told her, "and we'd like to visit your bakery. We thought you might be able to make us some brain-shaped cookies for our meetings."

"No! We don't do special orders," replied the woman, "and we don't take visitors." She quickly stepped back and slammed the door.

Decision Made

The NeuroExplorers flattened themselves against the wall of the porch, trying to stay out of the blowing rain as the storm got worse.

"Curiouser and Curiouser," The Brain said, rubbing his hands together as he looked around the mysterious building.

"I think that's a quote from 'Alice in Wonderland'," Max explained.

"This is no wonderland!" Lakeisha said, as the NeuroExplorers pushed together more tightly. "We'd better get out of here."

"What are we going to do now?" Isley I asked.

"Walk back to the bus stop and go home?" Isley II replied hopefully.

Kyle looked at the other NeuroExplorers, searching their eyes. Finally, he spoke. "Something's *weird* here. I say we snoop around a little. Maybe we can peek through a window or something—see what's going on."

"I believe there is consensus for that endeavor," The Brain replied.

"We all agree," said Max. "Let's take a look."

The NeuroExplorers tiptoed across the creaky porch, following its winding path around the side of the house.

"Shade's down," B.J. said, pressing her nose against the first window. "Can't see a thing." It looked as though every shade was down, every crack was sealed and every door locked.

At the very end of the porch was one last door. Lakeisha jiggled the handle. "I guess this one is locked too," she said.

Disappointment settled over the young explorers. Lakeisha sighed and leaned heavily against the door. "Well, I guess that's it," she said.

And it was! Because as Lakeisha leaned against the door, it opened, and she disappeared from sight, as if she had been swallowed up by the dark, old house.

Dark Voices

"Lakeisha, where are you?" the NeuroExplorers voiced in loud whispers, as each of them followed through the door from the gloom of a stormy day into the blackness of the closed-up old house.

As far as the Isleys were concerned, this was the darkest place they had ever been—even darker than the Caves at Calicoon! There were no lights, and every window was shaded. Only a dim light came through the still-open door. Staring into the darkness in the corner of the room, the Isleys were startled as something moved toward them through the gloom.

"What's that?" Isley I exclaimed.

"It's just me," Shiloh said, emerging from the darkness and rolling closer to the twins.

The Isleys relaxed. Now they could see the other NeuroExplorers. Nobody was speaking. But there *was* someone speaking—a voice, getting closer. It was a woman's voice. Kyle waved his hand, then held his finger to his lips.

"What do you *think* I did?" the voice said. "I sent them away."

"Are you sure they're gone?" a gruff man's voice answered.

"Yes. I checked. There's no one out front. They were just a bunch of kids anyway. It's nothing to worry about, Charlie," the woman said.

"I guess not," said Charlie. "I'm just a little nervous, Connie. After all, we still have more to do today. We haven't gotten all our phone calls yet, you know."

"We still haven't heard from the guy in Chicago?" Connie asked anxiously.

"No, and he said he'd order more if he liked the first one," Charlie replied.

"Okay, I'll stay near the phone," she said. "You go check the press."

The voices stopped and footsteps disappeared into other rooms.

"A most peculiar conversation," The Brain said, scratching his chin. No one looked at Max, because they understood. They all were thinking the exact same thing. This was very strange.

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A Sensory Plan

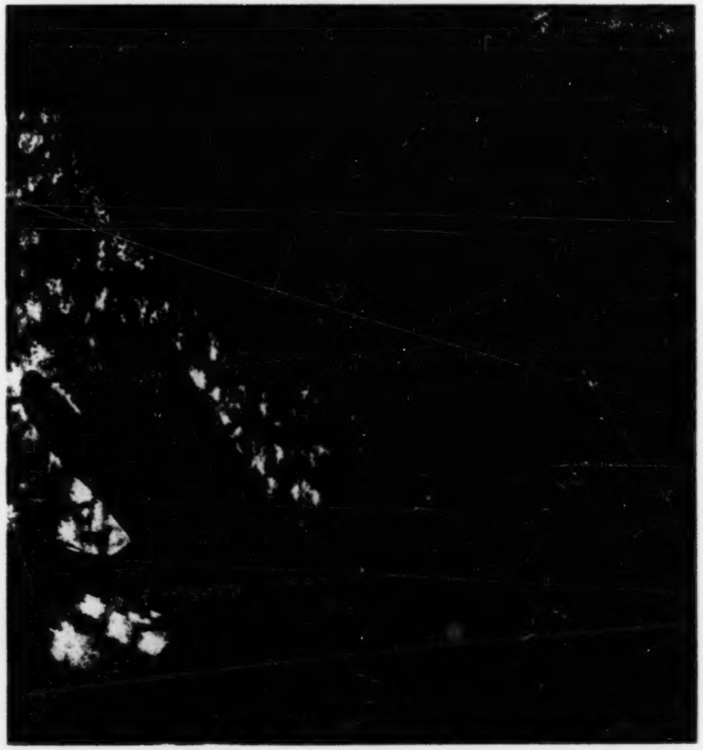
The NeuroExplorers didn't know what was going on or where they were in this dark house, but they all knew what they were going to do. There was a mystery here, and they would not turn away from it!

"We need a plan," B.J. said, twirling imaginary drumsticks.

"Teams," Isley I said.

"Right," continued Isley II. "We need to split into teams. Solving mysteries is just like sports. We need teamwork."

"The teams need to gather clues," Josh added, "to try and make some sense out of all this."



"That's it!" Kyle exclaimed. "You said it!"

"*What* did he say?" Isley I asked, peering through the darkness for Josh's face.

Kyle answered, "Let's make some sense out of this in the way we know best, using neuroscience. Let's use our *senses*!"

Lakeisha understood immediately. "Sense teams," she said. "We'll divide up into teams and gather clues by using our senses."

Excitedly, the NeuroExplorers started whispering back and forth. Who would be on the teams? Where would they go? What would they find?

Isley I and II were ready to go. They turned toward each other in the dark. "High five!" Isley I said, raising his hand and—hitting Kyle in the side of the face! Kyle's glasses flew off and his head snapped to the side.

"Ow!" Kyle cried out. "Isley! Be careful! Where did my glasses go?"

Scooping up Kyle's glasses, Lakeisha examined them. "One of the lenses is gone, Kyle, and they're bent," she said.

"Sorry," Isley I said. "I hope you don't need those to see!"

Isley II gave his brother a small shove. "This is no time for jokes, klutz," he said.

"Well, I guess you couldn't help it," said Kyle, fingering his useless eyeglasses. "It's too dark to see much around here anyway."

A calm voice spoke out—calm, but also confident. It was a voice with a plan. "I know what we can do," Shiloh announced, "and I know how we can do it."

Everyone Needs a Brain

Shiloh gently rocked her wheelchair back and forth while she talked. "We'll split up into four sense teams. Since tasting and smelling work together anyway, we can combine them in one team. The other teams will be seeing, touching and hearing."

Isley I spoke first. "Isley II and Kyle can be on the seeing team with me. We'll look for clues using our vision."

"If we had a thinking team, *you* couldn't be on it, Isley I!" his brother said. "Kyle won't be much of a vision partner without his glasses!"

"That's right," Shiloh added, "and Josh shouldn't be on the hearing team."

"But you can hear, can't you Josh?" asked Isley II.

"Yes, but only out of one ear," Josh answered. "When you hear with *both* ears, it's easier to figure out where sounds are coming from. Sometimes that helps!"

"I have a cold," Lakeisha said with a sniffle. "I won't be much good for the tasting and smelling team."

Shiloh nodded. In her head she was assembling teams, making plans and estimating outcomes. "Okay," she said finally, "here's how it will be. Lakeisha and B.J. will form the seeing team. Isley I and II will be the taste and smelling team." Shiloh spun her wheelchair to face the others. "Josh and Kyle will take the sense of touch, and The Brain and Max, hearing."

"What about you, Shiloh?" Kyle asked.

Josh stepped forward. He was looking at Shiloh with admiration. "That's easy," he said. "Shiloh obviously is the center of this nervous system. She's going to be the brain of our sensory network."

"Exactly!" Shiloh answered excitedly. "I'm going to stay right here. As soon as your sense team discovers a clue, come back here and tell me about it. I'll try to put them all together and make some sense of them."

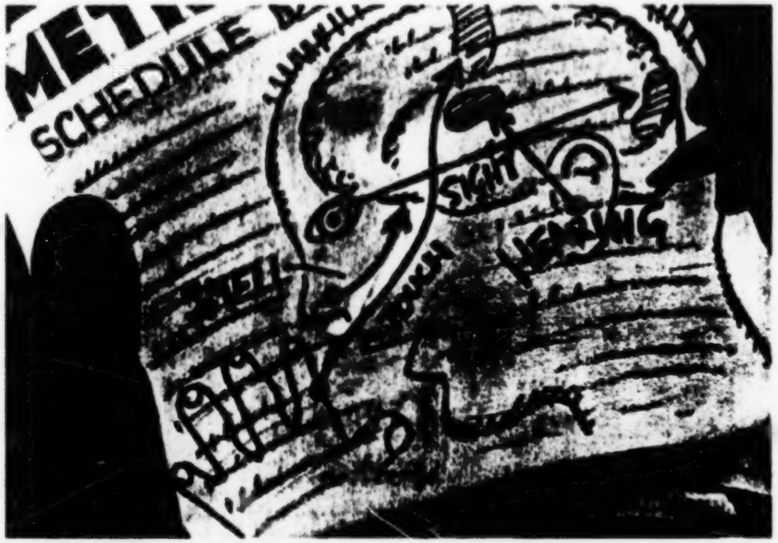
"Of course. Shiloh will be the center of integration and analysis—our cerebrum," The Brain added to himself. Pulling a pen from his pocket, he began to draw a brain on his bus schedule, with lines from each sense organ to show how sensory messages go to the brain.

"You can put all the sensory clues together, Shiloh, and try to come up with an answer," Max said, glancing at his friend's drawing. "It's perfect! Just like clues from all the senses are sent to the brains in our bodies!"

It was almost as if someone had turned on the lights, because now the NeuroExplorers could see clearly. The mystery was defined. They knew what they had to do. And they had a sensible way to do it.

Information about the world around us is detected by receptors in the nervous system. Each kind of receptor responds to a certain type of information. For example, receptors in the back of the eye detect light, and receptors on the tongue receive information about taste.

The information from each sense is processed in a different part of the brain. After sensory signals are received, they are sent to other areas of the cerebrum to be combined with other information. The amazing brain is able to put many different kinds of information together!



Bittersweet

After creeping along a dark, dusty hallway, the Isley twins found the kitchen. They weren't sure of the path they had followed and didn't know how they would get back to where they had been.

"We should have left a trail of crumbs," Isley I said.

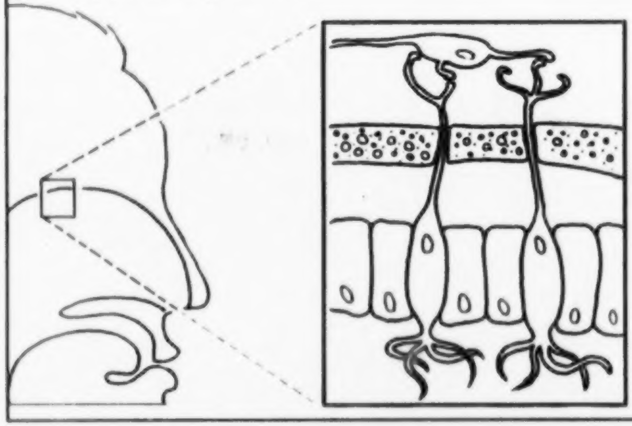
"I feel like I'm playing basketball with a blindfold on," Isley II said.

This surely was the kitchen. It smelled like something had been baking, and a faint heat still lingered around the ovens. A glimmer of light in the gloom showed pots and pans hanging from the ceiling like bats in a cave. There seemed to be boxes of cookies neatly stacked on large tables lining the walls.

"What do you smell?" Isley I asked his brother.

The sense of smell detects molecules that are carried in air. The molecules drift into the nose and stimulate special nerve cells, or receptors. The receptors send signals to the brain, telling it which odor is being smelled.

Often, the senses of smell and taste work together. To test this, try eating something while you hold your nose.



Isley II was unsure. "Baked things, I guess," he said.

"Yes, cookies—but there are other things too," Isley I said, taking a few slow sniffs. He bent close to a table top. "I think there was fresh ink on this table. And I smell oil, too, like machine oil."

"Hey," Isley II said, "that's amazing. How did you smell all those things?"

Isley I laughed quietly. "Maybe there are *some* things I do better than you."

"This tastes salty," Isley II announced suddenly from a far corner of the kitchen.

"Where are you? What are you doing? Don't taste anything unless you know what it is!" his brother said in a loud whisper.

"Over here," Isley II answered. "Don't worry. I just found the cookies. Hey, this one tastes sort of sweet. Here, try one."

Isley I stumbled over to Isley II and took a cookie from him. "Hmm," he said after biting off a small piece, "this cookie is *bitter*."

The twins tasted several cookies from different boxes. "They all taste a little different—and most of them aren't very good," Isley I said finally.

"This baker has no sense of taste," said Isley II. "I think we need to report this back to Shiloh."

Isley I didn't understand. "What for? Just because we tasted some bad cookies?"

"No, because it seems like Cousin Connie doesn't care how her cookies taste," Isley II answered. "Does that tell us anything?"

Isley I shook his head. "All it tells me is that she's a pretty bad cook."

"We need to report to Shiloh," Isley II insisted. "Let's go."

Visible Clues

In another part of the house, Lakeisha walked into a closed door, with a thump. "Ow! I can't see a thing!" she cried.

"Shhh," B.J. warned. "Of course you can't see. The lights are out!" she whispered. "*Light* has to go into your eyes before you can see, remember?"

"Okay, okay, I get the point," said Lakeisha, "but it doesn't help me right now."

"You're right," B.J. said. "Maybe it will be better on the other side of this door."

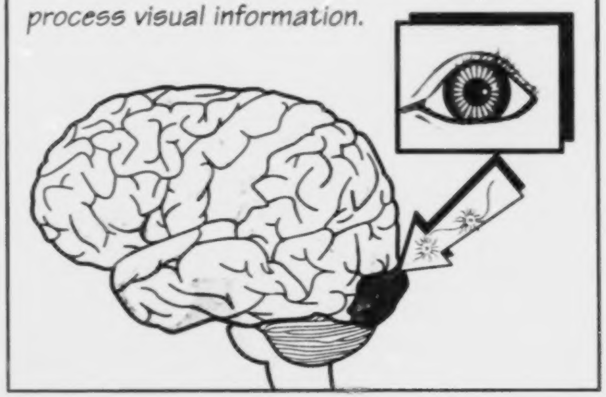
Lakeisha and B.J. entered yet another large, unlit room. This was the third in a row. They stumbled forward unsteadily.

"B.J.? I have a feeling we're not alone," Lakeisha said with a quiver.

B.J. swallowed hard. "What do you mean?" she whispered.

Light enters the eye through the pupil. The lens behind the pupil focuses light on the retina at the back of the eye. The retina consists of nerve cells that detect light and send messages about it back to the brain.

The primary visual cortex, where information from the eyes is received in the brain, is located at the back of the head. Over 20 other areas of the brain help process visual information.



"Well, my eyes are getting used to the dark, and there's something over there," Lakeisha said, "—something big and white over by the wall!"

B.J. squinted and stepped closer to the huge, ghostly thing, not daring to breathe. "It's...it's just a stack of boxes covered with a sheet!" she said with a sigh of relief.

"What's in them?" Lakeisha said. "Wait! I just remembered I have a flashlight on my keyring." She pulled it out. "It works!"

B.J. and Lakeisha quickly opened several boxes and held their contents up to the light of the tiny flashlight. They saw paper...all kinds of colored inks...cardboard...sheets of plastic.

"These aren't baking supplies," Lakeisha said. "We'd better go report this."

"But there are a few more rooms we should go through," B.J. protested.

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"I don't know," Lakeisha said. "This is kind of spooky."

"Are you scared?" B.J. asked.

"You bet!" said Lakeisha.

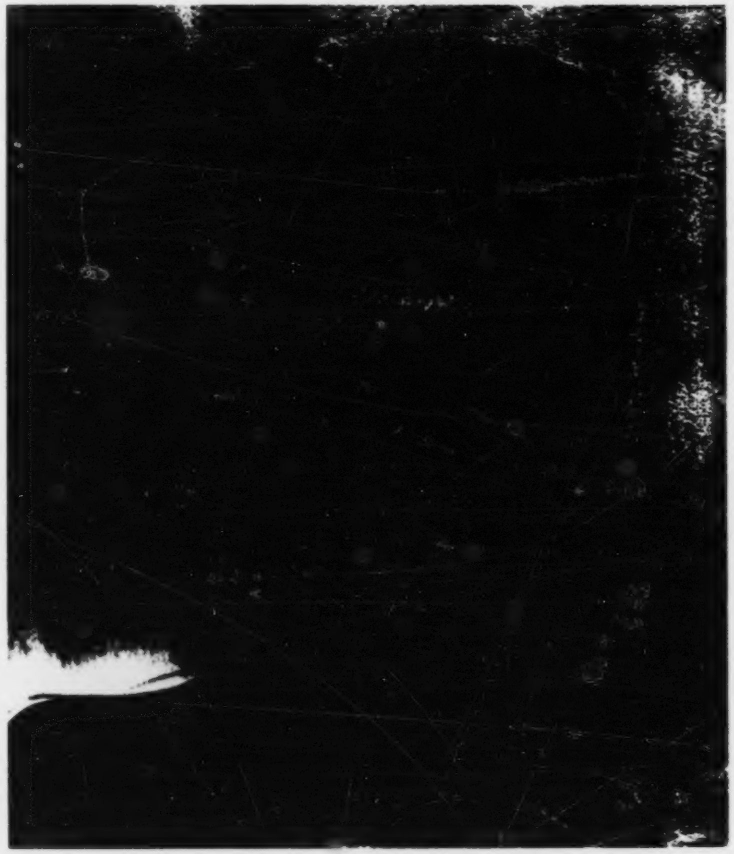
"So am I. Let's get out of here," said B.J., and she grabbed Lakeisha's hand.

Making Sense?

Rocking her wheelchair back and forth in the dark room, Shiloh considered the first clues. The Isleys had just left after reporting what they found—the smell of ink and machine oil, and bad-tasting cookies. Shiloh sent them back to sniff out more clues.

Her thoughts kept returning to the strange conversation they had heard between Connie and Charlie. Shiloh stopped rocking, tossed her head back and closed her eyes for a second to try to think harder.

"Shiloh, are you all right?" Lakeisha cried out as she entered the room.



Shiloh's eyes popped open. "Wha...Oh, yes, of course," she said. "I was just thinking. What did you see? Any clues?"

"We think so," said Lakeisha. "We saw something, but we're not sure what it means."

"Boxes," B.J. continued, drumming on a table with her fingers, "with paper, colored inks, cardboard, and sheets of plastic."

"Inks—sounds like *printing* supplies—but why would a bakery need those?" Shiloh muttered, half to herself. "Anyway, why don't you head back out. See what else you can see."

The two girls left Shiloh alone with her thoughts. Shiloh was at the center of the whole investigation, and she was concentrating, trying to put everything together as information came in from each of the sense teams.

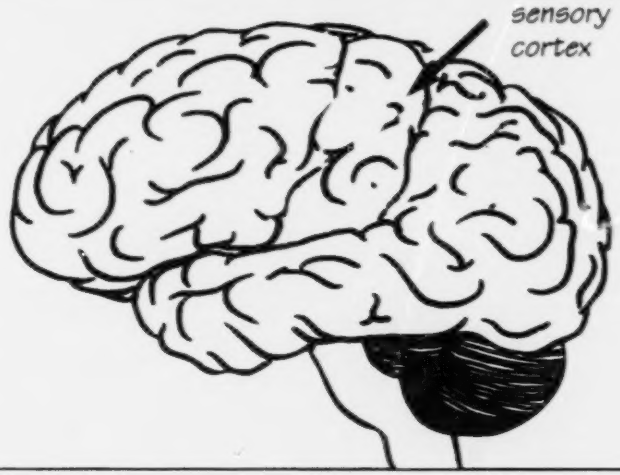
Feeling For Clues

Once, when he was a child, Josh hid in a hall closet that was filled with wool coats and black rainboots. That was pretty dark. He also remembered being caught in an elevator without electrical power. That was darker than night. Then he imagined outer space. Nothing Josh could imagine was as dark as this basement. Every window was shuttered and covered by a black cloth. It was total darkness.

Josh and Kyle inched along the walls. "We'd be lost without our sense of touch," Kyle commented.

"You mean we *aren't* lost?" Josh asked.

"No, I don't think so. We're in the basement, moving along an old wooden wall," Kyle answered calmly.



The sense of touch actually is made up of several different kinds of sensations. Each sensation is detected by a different receptor in the skin. There are receptors for hot and cold, pain and pressure, for example.

The sensory receptors send messages back to a special part of the brain called the sensory cortex. This part of the brain sits right behind the motor cortex, across the top of the head.

"A wooden wall? How do you know that?" Josh remarked.

"Use your fingers," Kyle replied. "It's the best way to learn things with your sense of touch."

"Ow!" Josh cried.

Kyle turned and squinted, but he still couldn't see Josh clearly. "What's the matter, Josh?" he said.

"Splinter. In my fingertip," Josh said, shaking his hand. "Thanks a lot!"

"That's another touch sensation—pain," said Kyle. "It lets your brain warn you not to do that again."

"Right," Josh said quickly. "It's telling me I don't want another splinter, so I'm not going to touch that wall again."

"Then you won't feel the vibration," Kyle said.

"What vibration?" asked Josh.

"The vibration in this wall," his friend answered.

Josh reached out, placed his palm carefully on the wall and felt it shaking just the tiniest bit. "Wow, you're right. Why is it doing that?" he said.

"I don't know," Kyle responded.

"Let's keep moving," Josh added. "Maybe we can find out what it is." The boys crept slowly around the room, clinging to the wall until they passed through a dark doorway and entered another unlit space.

"Stop," Kyle whispered suddenly. The two boys felt stronger vibrations in the wall. Somewhere in the distance was a faint, mechanical rumble.

"It must be a machine," Josh said. "It sounds just like a..."

"—a printing press, like down at the newspaper building," Kyle said.

"Yes," Josh said excitedly, "that's what...Wait a minute. I can feel more vibrations under my feet. Not like the steady shaking in the wall. Like clump-clump...like footsteps."

"Someone's coming," Kyle said, a little too loudly.

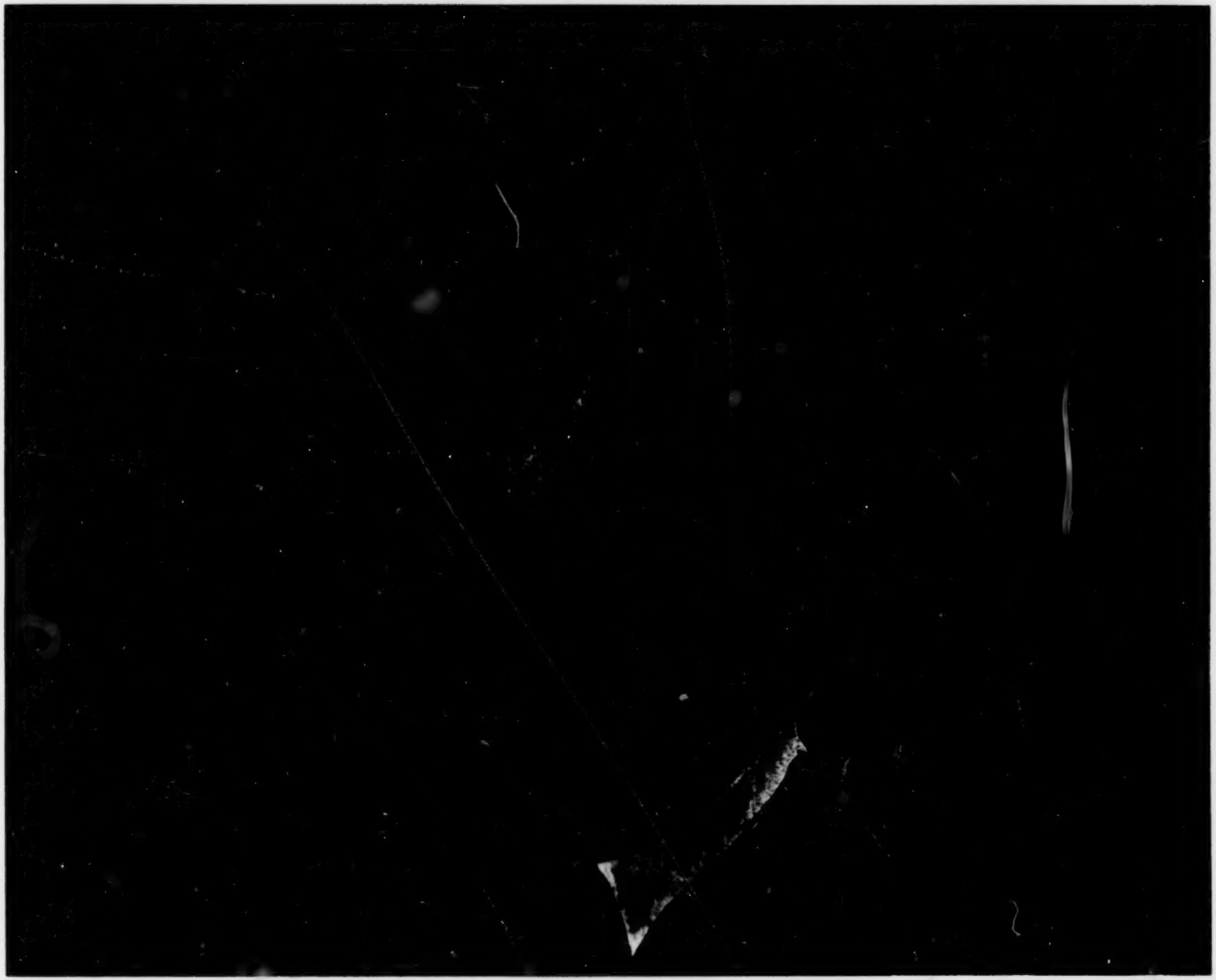
"Who's there?" A strange voice boomed from across the room. It wasn't the voice of a NeuroExplorer, that much they both knew.

"Go! Let's get out of here," Kyle yelled, breaking into a run.

In the pitch black cellar, Josh hesitated. Which way should he go? Footsteps were approaching, but he couldn't tell from which direction. Which way had Kyle gone?

Turning to his left, Josh ran—straight into the legs of Charlie, the man with Cousin Connie.

"What? Who are you?" the terrifyingly huge man growled, and he grabbed Josh and lifted him up by the shirt. Josh's legs danced crazily, running on air. "You're one of those kids!" Charlie said, holding Josh up to his face. "How'd you get here? You're coming with me."



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Sensing Danger

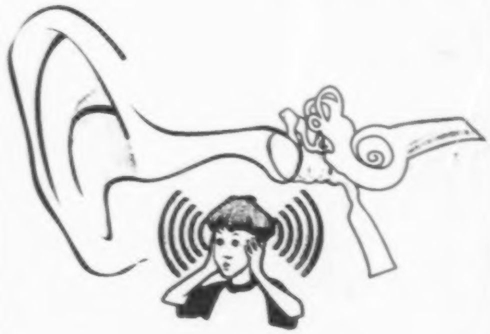
Kyle found his way back to Shiloh and quickly reported what he and Josh had found—mechanical vibrations that might be from a printing press. Then he told about the huge man, and how he and Josh got separated.

Shiloh nodded her head. "Thanks for the info," she said. "That adds a lot to the picture. But you'd better hurry back and try to find Josh!"

As soon as Kyle left, Shiloh started rocking her chair again. She was worried. The Isleys hadn't returned. She still hadn't heard from Max and The Brain, and now Josh was missing. Was this too dangerous for the NeuroExplorers?

Shiloh shook off her doubts. It was too late to turn back. She had better figure out what was going on—and fast!

Sound travels as waves of compressed air molecules. The ear captures sound waves and translates them into nervous system signals inside the inner ear. Information about sound is sent to a special part of the cerebrum.



The Better to Hear You With

The Brain and Max walked through three connecting rooms somewhere in the creepy old house. Each room seemed quieter than the last. "Maybe we should head back, Brain," Max said. "I haven't heard anything."

"Perhaps you aren't listening carefully enough," The Brain offered.

"Of course I'm listening," Max said quickly. "There's just no sound coming into my ears except your voice."

The Brain had his hands cupped around the backs of his ears. "Perhaps if you applied an assistive technique, your auditory sense would function more efficiently," he said to his friend.

"You mean you're hearing something by cupping your hands behind your ears?" Max replied. He copied The Brain's suggestion. "Hey, you're right!" he whispered. "I can hear a woman talking."

"I believe she's talking on the telephone," The Brain said. He placed his ear close to the wall, putting his cupped hand on its surface. "Listen," he said very softly.

They heard one side of a conversation. "Yes, of course we sent you the Mantle card....Why would I lie?...It should have gotten there long ago....I don't know, what should we do?...I see, right....Maybe there's another Joshua Kavil....That's possible....Yeah, I know. Then someone else gets the card....No, I'm not too worried. Whoever gets it will probably think it's just a dumb prize and throw it away....Sure, I know how much money it's worth!...Okay. No problem....Right. In today's mail....Okay. Bye."

The Brain turned and looked at Max. "We must relay this information to Shiloh with alacrity," he stated.

Max understood. They'd better report to Shiloh right away!

Putting It All Together

After telling Shiloh what they had heard, The Brain and Max turned to leave.

"Don't listen for any more clues," Shiloh told them. "I think we have enough—and we *may* have trouble. Kyle and Josh got separated. Why don't you go and try to find everybody and bring them back here, while I just try to put the pieces together?" The two boys nodded and set off in a hurry.

Shiloh felt that she had the last piece of the mystery. The telephone call put everything together for her. All of the NeuroExplorers had found important clues with their senses, and she was about to have the answer.

She went over the clues in her head. Cousin Connie wasn't interested in making tasty cookies, so she must be more interested in something else. But what? Printing supplies, the smell of ink and machine oil, along with the vibration of a printing press...Connie and Charlie were printing something. What were they printing? Not cookie boxes—baseball cards! Why go to all this trouble to print baseball cards? She thought about the telephone call. Suddenly Shiloh smiled. She had the answer.

But Shiloh's joy at solving the mystery suddenly turned into panic. Her friends were out there, in a dark house, with two *criminals*. Shiloh may have figured out what Cousin Connie was up to, but the NeuroExplorers could be in danger. She had to save them!

Caught in a Web

Charlie had The Brain by the arm and Max by the shirt. "Two more," he said gruffly, tossing the boys into a small room. Max and The Brain tumbled to the floor. "Do you think that's all of them?" Charlie said.

"Almost," Connie answered. "I know I saw one more. A girl. In a wheelchair. I'll go look for her. Keep these brats locked in here until I figure out what to do with them."

Connie and Charlie stormed out of the room, snapping the door shut behind them with a twist of the lock.

"Max?" a voice asked from the corner. Max recognized it as an Isley.

"Isley?" he said. "One," answered Isley I.

"And Two," another Isley voice said. NeuroExplorers' voices came from every shadow.

"I'm here too," said Lakeisha. "So is B.J."

"And me," Josh said, appearing from the side, "and Kyle too."

The NeuroExplorers all stood together near the center of the small room. It smelled dusty and musty. Using Lakeisha's flashlight, they could see a few cobweb-covered pieces of furniture, some boxes of old books, a rocking horse covered with dust—and no way out.

"This is big trouble," Isley II said. "These guys are serious."

"Why would they be this angry

just because we looked around their stupid cookie factory?" Isley I asked.

"Things are not what they seemed," The Brain announced. "We obviously have stumbled upon an illicit enterprise operating here."

"This isn't a cookie factory. These guys are crooks," Max interpreted, "and we are trapped like insects in a web!"

Big Trouble

The wheels of Shiloh's chair glided across creaky wooden floors as she maneuvered through dark hallways. If she couldn't find her friends, she must call the police. Where was a phone? Easing around corners, opening closed doors to eerie rooms, Shiloh finally found a desk with a dimly lit lamp on it—and a telephone! She raced across the room and grabbed the phone. Shiloh dialed 9-1-1. Each second seemed like an hour as she waited for her call to be answered.

Then she heard heavy footsteps behind her. A voice screeched, "No, you don't! Get away from there, you trouble-maker."

Cousin Connie grabbed Shiloh's arm, tore the phone out of her hand and jammed it back on its base. Somehow she seemed to wrap herself around Shiloh's whole upper body. Shiloh felt as though she were being strangled by a huge snake, and she couldn't move.

Connie shoved the chair and Shiloh across the room, out the door and on through the maze of the old house. They stopped by a door, and Shiloh could hear familiar voices. Here they were! At least she would be with the other NeuroExplorers. A hush fell in the room as the door opened and Shiloh was pushed inside.

Then the NeuroExplorers all talked at once. "Shiloh!...They got you

too....Now they've got us all."

"Not for long," Josh whispered, and he scooted out the open door before Cousin Connie could turn around to grab him.

"Come back here, kid!" the big woman shouted, fumbling for her key to lock the others in their prison. "Charlie!" she yelled. "Help me get that kid!"

All over the house, the small band of prisoners could hear the sounds of a chase—Running. Yelling. A telephone ringing. Then quiet. Still no Josh. Had he been caught? Did he get away? What was going on?

Even as they listened for clues, the NeuroExplorers began to question Shiloh, and she told them quickly what she had figured out from the information each of the sense teams had brought her.

A Sensational Ending

Finally, there was noise again outside the door of the NeuroExplorers' little prison cell. Now they could make out voices. "Okay, you two. Don't give us any trouble. Just take us to the kids." This was a voice they hadn't heard before.

“Here. This way. They’re over here.” That was Josh!

Once again, a key went in the lock and the door opened. Piling out of the small room and into a larger one, now lighted, the NeuroExplorers mobbed around their friend. Two police officers held Connie and Charlie by their arms and sat them down on boxes in the middle of the room.

One of the officers took out a note pad and said, “All right, now, let’s see what’s going on! We get here to check out a 911 and this boy crashes into my partner, here. These two are taking off down the street, and the boy says they’re crooks. So what’s the story?”

Josh jumped right in, hardly stopping for breath. “We found a baseball card in some horrible cookies that were delivered to my house. We decided to investigate, and we came here. We got in the house by accident, and we made sense teams, and Shiloh was the brain....”

“Wait a minute, son. Slow down,” interrupted a police officer. “Let’s back up a little. What were you all doing inside this house?”

“We’re the NeuroExplorers Club,” Kyle explained, “and we came here on a field trip. It’s a long story, but something looked fishy about this place, and we tried to find out what was going on. I guess we went a little too far.”

“Especially if you sensed something was wrong,” added one of the officers.

“That’s just it,” answered Josh, “we *sensed* something was wrong, but we weren’t sure, and it all just happened so fast. We decided to use our senses to try to find out what was going on and, all of a sudden, we were in trouble. We didn’t know they were crooks until they locked us up.”

“What?” asked a puzzled policeman. “You’ve lost me again!’

“We split up into teams and found sensory clues,” B.J. said.

“And just like neurons reporting information to the brain for processing, we all relayed our sense clues to Shiloh,” Max offered, “so Shiloh was the only one who had all the clues, and she came up with the answer.”

The Sensible Solution

"Cousin Connie's Cookie Company is just a front for a counterfeit operation," exclaimed Shiloh, somewhat proudly. "They aren't just printing baseball cards, they're *counterfeiting* them. The Mickey Mantle card Josh found is a counterfeit. The cookie business is a fake!"

"I'm still not sure I understand all of this, but I get the general idea," said one officer.

Shiloh continued, "Cousin Connie and Charlie were forging valuable baseball cards, hiding them in cookie boxes and shipping them to dealers to be sold as originals. Josh got a box by mistake because his name was the same as one of their customers. Cousin Connie and Charlie really are criminals!"

"Sounds like you're a pretty smart bunch of kids," said the other

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police officer, "but you could have been in serious trouble if Josh, here, hadn't been there to help us find you. He helped us catch this pair trying to get away, too."

"Come on," the officer said, "let's get you home safely before your folks get too worried. We'll take Cousin Connie and her pal down to the station for questioning."

The NeuroExplorers filed out of the house, still telling each other excitedly how important *their* sense had been in solving the puzzle, and how great Shiloh's brain had been in putting it all together.

Kyle looked at Josh and said, "I think we all *sense* that it's great to have you back, Josh. Good work!"

"An admirable case of sensory sleuthing, my friends!" The Brain added, his face breaking into a satisfied grin.

Glossary

Alzheimer's disease (ALLZ-hy-merz diz-eez) - a disease, found especially in older adults, that destroys cells of the central nervous system so that people can no longer remember or think properly

analysis (uh-NAL-uh-sis) - close examination by breaking up an idea or a substance into smaller parts in order to understand it better

archaeologist (ar-kee-AHL-uh-jist) - a scientist who studies the remains of past human life

brain (BRAYN) - the control center of the central nervous system, located within the skull and attached to the spinal cord; the command center of the body

cerebrum (suh-REE-brum) - the large, rounded outer layer of the brain where sensory input is received, thinking and learning occur and voluntary movement is started

Darwin, Charles (DAR-win) - a naturalist in the 1800s who studied plants and animals around the world and is known for his book, "On the Origin of Species"

decibel (DES-uh-buhl) - a unit for measuring intensity, or loudness, of sound

ear canal (EER kuh-nal) - part of the ear which leads from the outside of the head to the eardrum

eardrum (EER-drum) - a thin membrane, stretched tight inside the ear, which helps transmit sound waves to the inner part of the ear

epilepsy (EH-pih-lep-see) - a condition brought about by sudden changes in the brain that affect a person's awareness and actions, often with jerking movements of the body and limbs, for short periods of time

fracture (FRAK-cher) - a break, especially of a bone

inner ear (IN-er EER) - the inside part of the ear that functions in hearing and balance

integration (int-uh-GRAY-shun) - putting or bringing parts together to make a whole

lens (LENZ) - clear front part of eyeglasses that brings things into focus; also, part of the eye that focuses light on the retina

middle ear (MID-uhl EER) - a small cavity between the eardrum and the inner ear where three small bones pass sound waves along to the inner ear

motor neuron (MO-ter NU-rahn) - a type of nervous system cell, originating in the brain or the spinal cord, that sends impulses causing movement

nerve cell (NURV sel) - neuron; a cell of the nervous system that conducts a signal from one part of the body to another

nervous system (NER-vus sis-tum) - the brain, spinal cord and network of nerves in the body

neurologist (nu-RAHL-uh-jist) - a medical doctor specializing in the diagnosis and treatment of disease and injury in the nervous system

neurology (nu-RAHL-uh-gee) - a branch of medical science that deals with the nervous system

neuron (NU-rahn) - a cell of the nervous system that conducts a signal from one part of the body to another

neuroradiologist (nu-ro-ray-dee-AHL-uh-jist) - a medical doctor who uses pictures of the inside of the body (X rays and others) to identify injury and disease in the nervous system

neuroscience (NU-ro-SY-ens) - a branch of science related to the study of the nervous system

neurosurgeon (nu-ro-SUR-jun) - a medical doctor who specializes in operating on the brain, spinal cord and nerves

neurosurgical nurse (nu-ro-SUR-ji-kul NURS) - a nurse who is part of the team of people who perform surgery on the nervous system with a neurosurgeon

operation (ahp-uh-RA-shun) - an act performed on the body with surgical instruments to repair the effects of disease or injury

physician (fih-ZIH-shun) - a medical doctor

receptor (ree-SEP-tuhr) - a cell or group of cells that receive stimuli from outside the body; a sense organ

rehabilitation (ree-(h)uh-bil-uh-TA-shun) - the process of restoring a person to a condition of health or restoring the ability to function

retina (RET-i-nuh) - sensory membrane at the back of the eyeball that converts light to neuronal activity that travels along the optic nerve to the brain

sensation (sen-SA-shun) - an awareness of stimulation of any of the senses, as sight, smell, touch, etc.

sense (SENS) - (1) a function of the body by which one is made aware of the world outside, as sight, hearing, touch, smell or taste; (2) a feeling or awareness; (3) to become aware of; (4) clear understanding or good judgment

sensory receptor (SENS-uh-ree ree-SEP-tuhr) - a part of the body by which one receives information from the outside, as the eyes for seeing, ears for hearing, etc.

sensory network (SENS-uh-ree NET-wurk) - all of the parts of the body involved in receiving and transmitting sensory information (sensory receptors, neurons, and the brain)

skull (SKUL) - all the bones of the head, including the cranium and the facial bones

sound wave (SOWND wayv) - a kind of vibration that travels through a substance, such as air, and can be heard

spinal cord (SPY-nuhl kord) - the thin rope of nervous tissue inside the bones of the spine

therapy (THAIR-uh-pee) - treatment to heal or improve the effects of a bodily disorder, illness or injury

tissue (TIH-shoo) - many cells of the same kind, joined together to do a specific job

vibration (vy-BRAY-shun) - a quivering or trembling motion

visual cortex (VIZH-uh-wuhl KOR-teks) - part of the cerebrum that receives information from the eyes

Grace Boyle was a teacher in Hempstead, New York for 20 years and received her M.S. degree in Elementary Administration from Hofstra University. She developed, coordinated and implemented a program for gifted and talented students in the Hempstead school system. Ms. Boyle has written curriculum materials for several textbook publishers, specializing in activity books that encourage children's critical thinking skills and stories that promote scientific curiosity. Currently, Ms. Boyle is a freelance writer. Her son, Dr. Thomas P. Boyle, a Florida radiologist, serves as consultant for her science-based writing.

T Lewis was born in Texas but has travelled extensively, living in such locales as Africa, Switzerland and Alaska. Currently, he lives in a small town in the state of Washington with his wife and young son. While his broad range of artwork has appeared in many formats, he is especially fond of creating illustrations for children. Recent books bearing his work are *Bedtime Rhymes from Around the World* and *Cinderella: The Untold Story*. He has drawn the Mickey Mouse comic strip for Disney Productions and is one of the creators of *Over the Hedge*, a comic strip in national syndication.

Faculty members in the Division of School-Based Programs at Baylor College of Medicine in Houston, Texas, have developed and revised instructional materials for the BrainLink® project. Judith Dresden, Barbara Tharp and Nancy Moreno have been working together at Baylor for several years on science education projects involving teachers and students from kindergarten through college. All are parents of teenage or grown children. As a team, they also have created instructional materials for the My Health My World™ project, which focuses on environmental health science for elementary school students.

Judith Dresden, originally from New York and New England, formerly conducted educational research and evaluation for public and private schools. Editorial work with a publishing company also led to her current interest in writing and editing stories and science activities for children. She directs the BrainLink project at Baylor and at regional centers around the country. Other projects involve promoting minority students' access to careers in science and the health professions.

Barbara Tharp, originally from California, once worked for the FBI in Washington, D.C., and later was an economic analyst for an oil company. More recently, she has been an elementary teacher specializing in her favorite subjects, science and math. Currently, in addition to creating educational materials, she also enjoys working with many classroom teachers and their students. She directs elementary school teacher enhancement programs at Baylor.

Nancy Moreno, originally from Wisconsin and Michigan, is a biologist who specializes in botany. She spent considerable time studying neotropical plants in Mexico before completing her doctoral degree at Rice University. Current interests include involving scientists in pre-college education. She oversees the science content of Baylor's elementary curriculum development projects and directs the My Health My World project, which builds upon her special interests in ecology and environmental issues.

WOW™ Publications

BrainLink® Adventures
Developed by
Baylor College of Medicine
Houston, Texas
ISBN 1-888997-19-2

BrainLink
SENSORY SIGNALS

ACTIVITIES

GUIDE FOR TEACHERS

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The **BrainLink®** series for health and science education provides:

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TROUBLE AT TSAVO

The Cookie Crumbles
Sensory Signals

EXPLORATIONS
ACTIVITIES
THE COOKIE CRUMBLES

Danger at Rocky River
Memory & Learning

EXPLORATIONS
ACTIVITIES

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BrainLink®

ACTIVITIES

GUIDE FOR TEACHERS

Sensory Signals

Revised Edition

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Leslie Miller, Ph.D.
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Printed in the United States of America
WOW! Publications, Inc.

15 14 13 12 11 10 9 8 7 6 5 4 3 2 1

ISBN: 1-888997-23-0

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The activities described in this book are intended for school-age children under direct supervision of adults. The authors, Baylor College of Medicine and the publisher cannot be responsible for any accidents or injuries that may result from conduct of the activities, from not specifically following directions, or from ignoring cautions contained in the text.

Development of BrainLink® educational materials was supported, in part, by funds from the National Institutes of Health, Science Education Partnership Award grant number R25 RR09833 to Baylor College of Medicine. The opinions, findings and conclusions expressed in this publication are solely those of the authors and do not necessarily reflect the views of Baylor College of Medicine, the sponsoring agency, or the publisher.

Cover design: Bob Peretti
Design and production: Kerrie Kerns
Illustrations: Kerrie Kerns, Rhonda Flemming and T Lewis

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Science and Health for Kids!

These BrainLink Activities are designed to be used with other components of the Sensory Signals unit:

BrainLink Adventures
The Cookie Crumbles: The NeuroExplorers™ in a Case of Sensory Sleuthing

BrainLink Explorations
Sensory Signals

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ACKNOWLEDGMENTS

The BrainLink project at Baylor College of Medicine has benefited from the vision and expertise of scientists and educators from a wide range of specialties. Our heartfelt appreciation goes to James Patrick, Ph.D., Professor and Head of the Division of Neuroscience, Stanley Appel, M.D., Professor and Chairman of Neurology, and Carlos Vallbona, M.D., Distinguished Service Professor and Chairman of Community Medicine at Baylor College of Medicine, who have lent their support and expertise to the project. We also express our gratitude to Leslie Miller, Ph.D., who assembled the original BrainLink development team and guided the BrainLink project through its first years, and to Cynthia Bandemer, M.P.H., Director of Education, Houston Museum of Health and Medical Science, who directed BrainLink activities sponsored by the Harris County Medical Society.

Members of the original BrainLink steering committee provided much valued vision and inspiration for shaping the original direction and design of the project: Terry Contant, Ph.D.; Barbara Foots, M.S.; Anne Hayman, Ph.D.; Judith Livingston, M.Ed.; Christina Meyers, Ph.D.; Kathleen Philbin, Ph.D.; Carolyn Sumners, Ed.D.; and Katherine Taber, Ph.D.

Several colleagues provided guidance during the production of this guide. In particular, we would like to offer our special thanks to: Scott Bassinger, Ph.D.; Francis Catlin, M.D.; Celia Clay, M.P.H.; Dane Chetkovich, M.D., Ph.D.; Ruthanne Eatock, Ph.D.; Ron Fields, Ph.D.; John Maunsell, Ph.D.; Sarah Pallas, Ph.D.; and Samuel Wu, Ph.D.

Special thanks go to the National Institutes of Health, Science Education Partnership Award Program, to Marjorie A. Tingle, Ph.D. and to Robert Hendrickson, Ph.D. for their support of the BrainLink project.

We are especially grateful to the many classroom teachers in the Houston area who eagerly participated in the field tests of these materials and provided invaluable feedback.

BrainLink Project Director: Judith Dresden, M.S.
BrainLink Project Co-director: William Thomson, Ph.D.
BrainLink Project Faculty: Barbara Tharp, M.S. and Nancy Moreno, Ph.D.

> **"The brain is the last and grandest biological frontier, the most complex thing we have yet discovered in our universe. It contains hundreds of billions of cells interlinked through trillions of connections. The brain boggles the mind."**
>
> James D. Watson
> from *Discovering the Brain*
> National Academy Press
> 1992

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ABOUT BRAINLINK - Science and Health for Kids!

The BrainLink Project's exciting *Activities*, *Explorations* and *Adventures* "link" students, teachers and parents to advanced knowledge of the brain and nervous system and to vital science and health information. Prepared by teams of educators, scientists and health specialists, each BrainLink unit focuses on a different aspect of the brain and the nervous system. The activity-based, discovery-oriented approach of the BrainLink materials is aligned with the *National Science Education Standards* and the *National Health Education Standards.*

The three components of each BrainLink unit help students learn why their brains make them special.

- *BrainLink Adventures* presents the escapades of the NeuroExplorers Club in an illustrated storybook that also teaches science and health concepts.

THE COOKIE CRUMBLES.

- *BrainLink Explorations for Children and Adults* is a colorful mini-magazine full of information, activities and fun things to do in class or at home.

EXPLORATIONS.
FOR CHILDREN AND ADULTS

- *BrainLink Activities - Guide for Teachers* presents activity-based lessons that entice students to discover concepts in science, mathematics and health through hands-on activities.

ACTIVITIES
GUIDE FOR TEACHERS

BrainLink materials offer flexibility and versatility and are adaptable to a variety of teaching and learning styles.

WHERE DO I BEGIN?

The *Adventures, Explorations* and *Activities* components of each BrainLink unit are designed to be used together to introduce and reinforce important concepts for students. To begin a BrainLink unit, some teachers prefer to generate students' interest by reading part or all of the *Adventures* story. Others use the cover of the *Explorations* mini-magazine as a way to create student enthusiasm and introduce the unit. Still others begin with the first discovery lesson in the *BrainLink Activities - Guide for Teachers.*

If this is your first BrainLink unit, you may want to use the pacing chart on the following page as a guide to integrating the three components of the unit into your schedule. When teaching BrainLink for 45 to 60 minutes daily, most teachers will complete an entire BrainLink unit with their students in two to three weeks. If you use BrainLink every other day or once per week, one unit will take from three to nine weeks to teach, depending on the amount of time you spend on each session.

The *BrainLink Activities - Guide for Teachers* provides background information for you, the teacher, at the beginning of each activity. In addition, a listing of all materials, estimates of time needed to conduct activities and links to other components of the unit are given as aids for planning. Questioning strategies, follow-up activities and appropriate treatments for student-generated data also are provided. The final activity in each *BrainLink Activities - Guide for Teachers* is appropriate for assessing student mastery of concepts.

Using Cooperative Groups in the Classroom

Cooperative learning is a systematic way for students to work together in groups of two to four. It provides an organized setting for group interaction and enables students to share ideas and to learn from one another. Through such interactions, students are more likely to take responsibility for their own learning. The use of cooperative groups provides necessary support for reluctant learners, models community settings where cooperation is necessary, and enables the teacher to conduct hands-on investigations with fewer materials.

Organization is essential for cooperative learning to occur in a hands-on science classroom. There are materials to be managed, processes to be performed, results to be recorded and clean-up procedures to be followed. When students are "doing" science, each student must have a specific role, or chaos may follow.

The Teaming Up model* provides an efficient system. Four "jobs" are delineated: Principal Investigator, Materials Manager, Reporter, and Maintenance Director. Each job entails specific responsibilities. Students wear job badges that describe their duties. Tasks are rotated within each group for different activities, so that each student has an opportunity to experience all roles. Teachers even may want to make class charts to coordinate job assignments within groups.

Once a cooperative model for learning has been established in the classroom, students are able to conduct science activities in an organized and effective manner. All students are aware of their responsibilities and are able to contribute to successful group efforts.

* Jones, R. M. 1990. Teaming Up! LaPorte, Texas: ITGROUP.

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Sensory Signals
Sample Sequence of Activities, Adventures and Explorations

The components of this BrainLink unit can be used together in many ways. If you have never used these materials before, the following outline might help you to coordinate the Activities described in this book with the unit's *Adventure* story (*The Cookie Crumbles*) and *Explorations* mini-magazine (*Sensory Signals*).

Similar information also is provided for you in the Links section of each activity in this book.

Activity	Concepts	Class Periods to Complete Activity	Links to Other Components of Unit	
			Adventures: Cookie Crumbles	**Explorations: Sensory Signals**
1. Windows to the World	Senses provide us with information about the world.	1	**Read:** A Friend Returns; Cross-Wired; Mystery Cookies	Cover page activity; The Neuro Side (p 7)
2. Putting It All Together	Different areas of the cerebrum receive information from the senses.	1	**Read:** NeuroExplorers In Action; Cousin Connie's Cookie Company	Gray Matters (p 2); Is Seeing Believing? (p 3)
3. SensePhone	The brain receives and integrates information from the senses.	1 or 2	**Read:** Decision Made; Dark Voices	Gray Matters (p 2); Sensible Games (p 5)
4. Vision and Illusions	Optical illusions provide clues about how the brain processes visual information.	1 or 2	**Read:** A Sensory Plan; Everyone Needs a Brain	Is Seeing Believing? (p 3); Use Your Brain—Promote Your Health (p 4); Sensible Games (p 5)
5. Can You Hear Me?	Some kinds of hearing loss are preventable.	1	**Read:** Bittersweet; Visible Clues	Gray Matters (p 2); Decade of the Brain (p 4); Sensible Games (p 5)
6. Tactile Tests	The sense of touch varies on different parts of the body.	1	**Read:** Making Sense?; Feeling for Clues	Cover Activity; Gray Matters (p 2); Careers for NeuroExplorers (p 7)
7. Get the Point?	Receptors in the skin receive information from within their receptive fields.	1	**Read:** Sensing Danger; The Better to Hear You With	Cover Activity; Gray Matters (p 2)
8. My Sensory Strip	The sensory cortex receives information from receptors in the skin.	1	**Read:** Putting It All Together; Caught in a Web; Big Trouble	Gray Matters (p 2)
9. Use Your Brains, Create Refrains	Summary of concepts and assessment	*	**Read:** A Sensational Ending; The Sensible Solution	Gray Matters (p 2); Decade of the Brain

Materials

You will need the following materials to teach this unit.

- package of popped popcorn, buttered and salted (Activity 1)
- package of unpopped popcorn, no salt, no butter (Activity 1)
- hot air or other popcorn popper (Activity 1)
- two identical opaque plastic bags (Activity 1)
- colored markers or crayons (Activities 2 and 3)
- scissors (one per student or group) (Activities 3 and 8)
- 15 meters of medium weight string per group of six students (Activity 3)
- six disposable cups (8 oz size) per group of six students (Activity 3)
- small box of paper clips (Activities 3, 6 and 7)
- hand magnifiers (one per student or pair of students) (Activity 4)
- white notecards (one per student) (Activity 4)
- disposable ear plugs (one pair per student) (Activity 5)
- cassette or compact disc player and tapes or compact discs (Activity 5)
- paper lunch bags (one per pair of students) (Activity 6)
- pairs of similar tactile materials, for example: penny and washer, cotton and fur, fine and coarse sandpaper, newsprint and copy paper, foil and wax paper) (Activity 6)
- rulers (one per student or group) (Activities 7 and 8; for Activity 8, rulers should be divided in millimeters)
- clear tape (one roll per group) (Activities 7 and 8)
- pipe cleaners (one per student) (Activity 8)
- glue (Activity 8, if not using tape)

Call 1-800-969-4996 for information about BrainLink printed materials and supplies.

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Windows to the World

BRAINLINK BACKGROUND (for the teacher)

Our senses are our "windows to the world." Through the senses, we obtain information necessary for survival. Like all other forms of life, we need to interact with our surroundings to obtain nutrients, protect ourselves from danger and reproduce. Senses also work within our bodies to provide cues about varying states of our body organs and positions of our muscles and limbs.

Simple one-celled organisms, such as the amoeba, detect light, temperature and other characteristics of the environment over much of their external surfaces. More complex animals have evolved specialized cells called *receptors* that respond to specific aspects of their environments by sending messages to the rest of the nervous system. Receptors translate information about the physical world and conditions inside the body into impulses that travel along neurons. Most receptors are specialized to respond best to a particular kind of stimulus. Thus, the simple nerve endings in the skin respond to pressure or temperature, while rods and cones, receptors in the back of the eye, react only to the presence of different kinds of light.

Specialized regions within the brain receive and integrate information detected by sensory receptors. Through this process, we are able to interpret and react to our environment. Senses enable us to participate in the world—to learn, to achieve, to discover, to communicate.

Taste and smell, in particular, are emphasized as students embark on a sensory exploration that introduces this unit of BrainLink activities. You may wish to highlight some of the interesting facts about taste and smell listed on the following page.

LINKS

This activity may be taught along with the following components of the Sensory Signals unit.

***Cookie Crumbles* chapters:**

A Friend Returns
Cross-Wired
Mystery Cookies (see science box on page 18)
NOTE: If this is your students' first BrainLink Adventure story, have them read the introductory sections of the book—The Beginning and The Club Members—before continuing with the chapters listed above.

Explorations:

Cover page activity

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ACTIVITY 1

CONCEPTS

- Senses provide us with information about the world around us.
- Senses provide information from within the body.

OVERVIEW

Students conduct an exploration using all five senses.

SCIENCE & MATH SKILLS

Observing, predicting and drawing conclusions

TIME

Preparation: 15 minutes
Class: 30 minutes

MATERIALS

- plain, unpopped popcorn
- apparatus for popping corn
- buttered, salted popcorn (previously prepared or purchased)
- 2 identical opaque plastic bags

The senses are our "windows to the world."

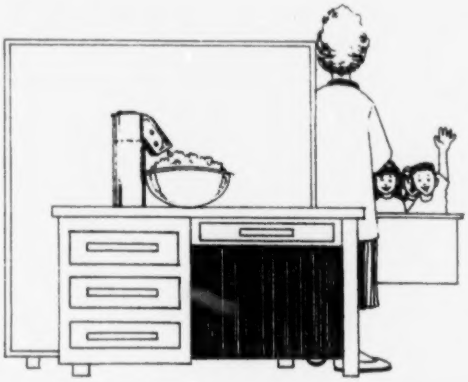
SET-UP

Conduct this discovery lesson with the entire class. The activity will lead students to think about the basic scientific questions, *What do you think is happening?* and *How do you know?*

Pop or purchase buttered, salted popcorn before class and put it in an opaque plastic bag. Bring plain, unpopped popcorn (no butter or salt) to be prepared in class.

PROCEDURE

1. Conceal a popcorn popper behind a desk or screen and begin popping the corn. Ask the students to sit quietly at their desks. As the kernels begin to pop, ask, *What do you think is happening behind the screen?* When students respond that you are making popcorn, ask, *How do you know?* If only one sense is mentioned, ask, *What else tells you it's popcorn?*



2. Without allowing students to watch, put the warm, newly-popped corn into a bag identical to the one containing the buttered, salted popcorn. Bring out both bags. Ask, *How could you tell which batch was just popped?* Let the students touch the bags. Again, ask, *Which batch was just popped? What makes you think so?*
3. Now ask, *Is either batch flavored? How could you tell?* Allow students to smell the popcorn from each batch without peeking into the bag. Ask, *Are they the same or different? How are they different?*
4. Finally ask, *Are either or both batches salted? How could you find out?* Allow one or all students to taste one kernel from each batch.
5. Conclude by conducting a discussion with the students about how they were able to solve the popcorn mystery. If students have not yet mentioned "senses," introduce the concept.

Taste and Smell Facts

- Taste and smell depend on receptors that normally are stimulated by chemicals. Molecules dissolved in liquid are detected by receptors on the tongue. Molecules carried in air are recognized by receptors inside the nose.
- Even though the sense of smell is about 10,000 times as sensitive as taste, the senses of smell and taste usually work in concert, allowing us to distinguish among thousands of different odors and flavors.
- There are about 10,000 receptor units or taste buds organized in small clusters on the tongue.
- While the four basic tastes—sweet, sour, salty and bitter—can be detected over most of the tongue's surface, certain regions are more responsive to a particular taste. The tip of the tongue is most sensitive to sweet, the front and sides to salt, the sides at the very back to sour and the center back to bitter.

Ask students which bag contains recently popped corn.

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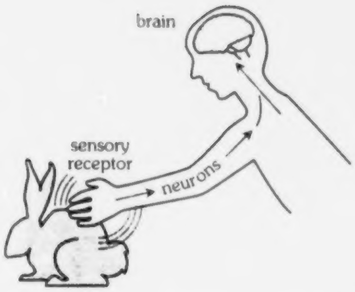
Senses bring information about inside and outside the body to the brain. Very briefly discuss the common senses (sight, hearing, smell, taste, touch/feeling).

6. Ask the students to tell you all the parts of the body and the nervous system that they used in this exploration (eyes, nose, mouth, tongue, ears, fingers, brain, neurons, etc.)

7. Stimulate further discussion by asking, *What did your brain do? How did the information get from the sense organs (eye, ear, fingers, nose, etc.) to the brain?* These questions will build interest for Activity 2.

8. Draw a simple diagram on the board, as shown, to illustrate the relationship between detecting a stimulus, sending a message to the brain and interpreting the message in the brain.



Make a simple diagram of sensory pathways on the board.

BRAIN JOGGING

Here are more ideas for you and your students to explore.

- What do you think a sense is? Is the ability to detect the passage of time a sense? How about balance? Hunger? Detecting gravity?
- Can you think of anything that you do or have ever done without using any of your senses?
- Some people believe that our brains can receive information directly. This controversial phenomenon is called extrasensory perception (ESP). What does the word, "extrasensory," mean? Do you think that it's possible for the brain to receive information that does not pass through the sensory system?

Putting It All Together

BRAINLINK BACKGROUND (for the teacher)

Certain parts of the brain are dedicated to each sense. Initially, different areas of the cerebrum are responsible for receiving messages from each kind of sense organ. For example, a specific region of the cerebrum in the back of the brain is dedicated to receiving information from the eyes. Not only are areas of the brain specialized with regard to the senses, but scientists have discovered that, within each specialized area of the brain, neurons respond to particular aspects of sensory information. In the visual region, for instance, some neurons are devoted to motion, others to color, and yet others to shapes and patterns. The diagram at the bottom of the page shows the primary sensory processing area (*sensory cortex*) for each of the five senses. While not shown on the drawing, it should be noted that all sensory information is routed through a central location deep inside the brain (known as the thalamus), before being sent to the appropriate sensory area.

After sensory signals are initially processed, they are forwarded to other areas of the cerebrum for more complex integration. In addition, there are areas in the cerebrum where the brain puts together information from all the senses. When we obtain information from several senses, we often are better able to understand a situation than when we have only one form of sensory input.

ACTIVITY 2

CONCEPTS

- Different areas of the cerebrum receive information from each sense.

OVERVIEW

Students learn about the special areas of the brain that receive information from the senses.

SCIENCE & MATH SKILLS

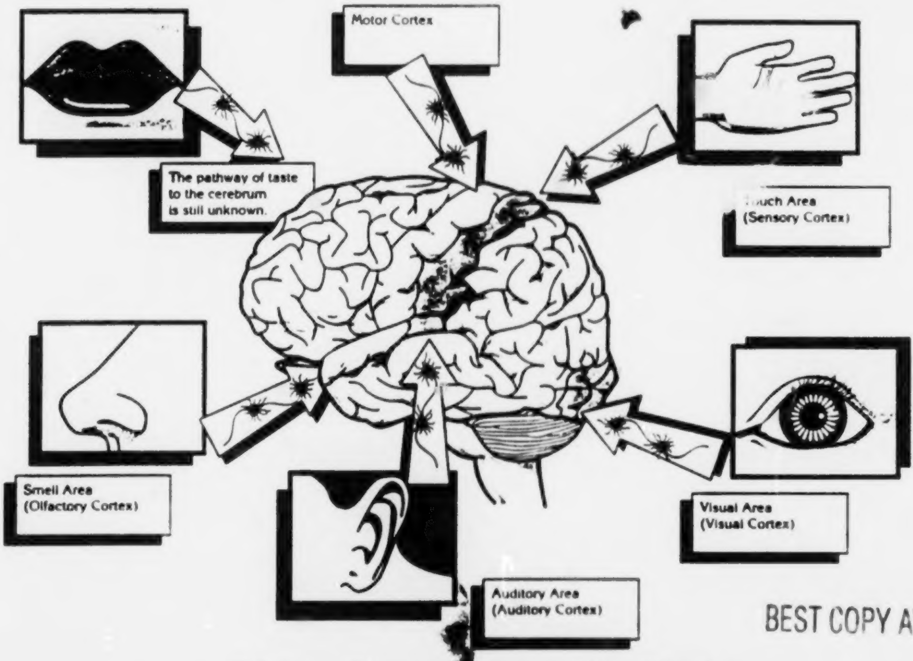
Modeling and inferring

TIME

Preparation: 5 minutes
Class: 30 minutes

MATERIALS

- copies or overhead transparency of "Sensory Areas of the Cerebrum" on page 6
- copies of "Sensory NeuroKid" on page 7 (one per student)


Motor Cortex
The pathway of taste to the cerebrum is still unknown.
Touch Area (Sensory Cortex)
Smell Area (Olfactory Cortex)
Visual Area (Visual Cortex)
Auditory Area (Auditory Cortex)

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Primary Sensory Areas of the Cerebrum

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LINKS

This activity may be taught along with the following components of the Sensory Signals unit.

The Cookie Crumbles chapters:
NeuroExplorers in Action
Cousin Connie's Cookie Company
Explorations:
Gray Matters (page 2)
Is Seeing Believing? (page 3)
Sensible Games (page 5)

SET-UP

Conduct this activity with the entire class.

PROCEDURE

1. Project an overhead or distribute copies of the Sensory Areas of the Cerebrum page. Have students identify basic parts of the brain (such as cerebrum, cerebellum and brainstem) before pointing out the special areas where information from each sense is first processed. Ask, *Can you find where information about things we see is sent? About things we smell? About things we hear?*
2. Give each student a copy of the NeuroKid page. Have the students draw a line from each sensory stimulus (lamp, food, radio, etc.) to the primary receptor organ associated with it (eye, ear, tongue), and on to the area of the cerebrum where that particular sensory information is processed.
3. You may want to assign a specific color for each sense to make the diagram easier to follow. Students may use that color to fill in the corresponding area of cerebral cortex.
4. Note that the stimuli may evoke more than one sensory response. For example, food can be tasted, smelled, seen and touched. After their initial responses, urge older students to note all the senses that could be stimulated by each item.

BRAIN JOGGING

Here is another idea for you and your students to explore.

Which sense do you usually rely upon most? Explain why that sense is more important to you compared to all your other senses.

Unusual Animal Senses

There are many fascinating ways in which different animals "sense" their environments through distinct sets of "windows," or senses. Each organism is sensitive to only a portion of the information available in the environment. Animals have evolved different types of "windows" depending upon the particular environment in which they live and what, specifically, they need to know about their surroundings in order to survive long enough to produce offspring.

Did you know that:

- Mosquitoes are able to detect the presence of potential prey by sensing the carbon dioxide (CO_2) given off as waste from animal respiration?
- Crabs and flies taste with their feet, allowing them to know immediately if they have landed upon something edible?

- Some male moths can smell and then locate a potential mate several miles away by detecting airborne chemicals (pheromones) produced by the female?
- Bats and whales send out sound signals and monitor the echo to assess the nearness of obstacles, danger and food (echolocation)?
- Homing pigeons and other birds are believed to sense the earth's magnetic fields and use that information for navigation?

- Electric fish generate electric fields around themselves that allow them to detect objects in their immediate vicinity?
- Rattlesnakes use a special organ (the pit organ) to locate other animals, even in total darkness, by seeing an aura indicating the warmth of the other animal's body?

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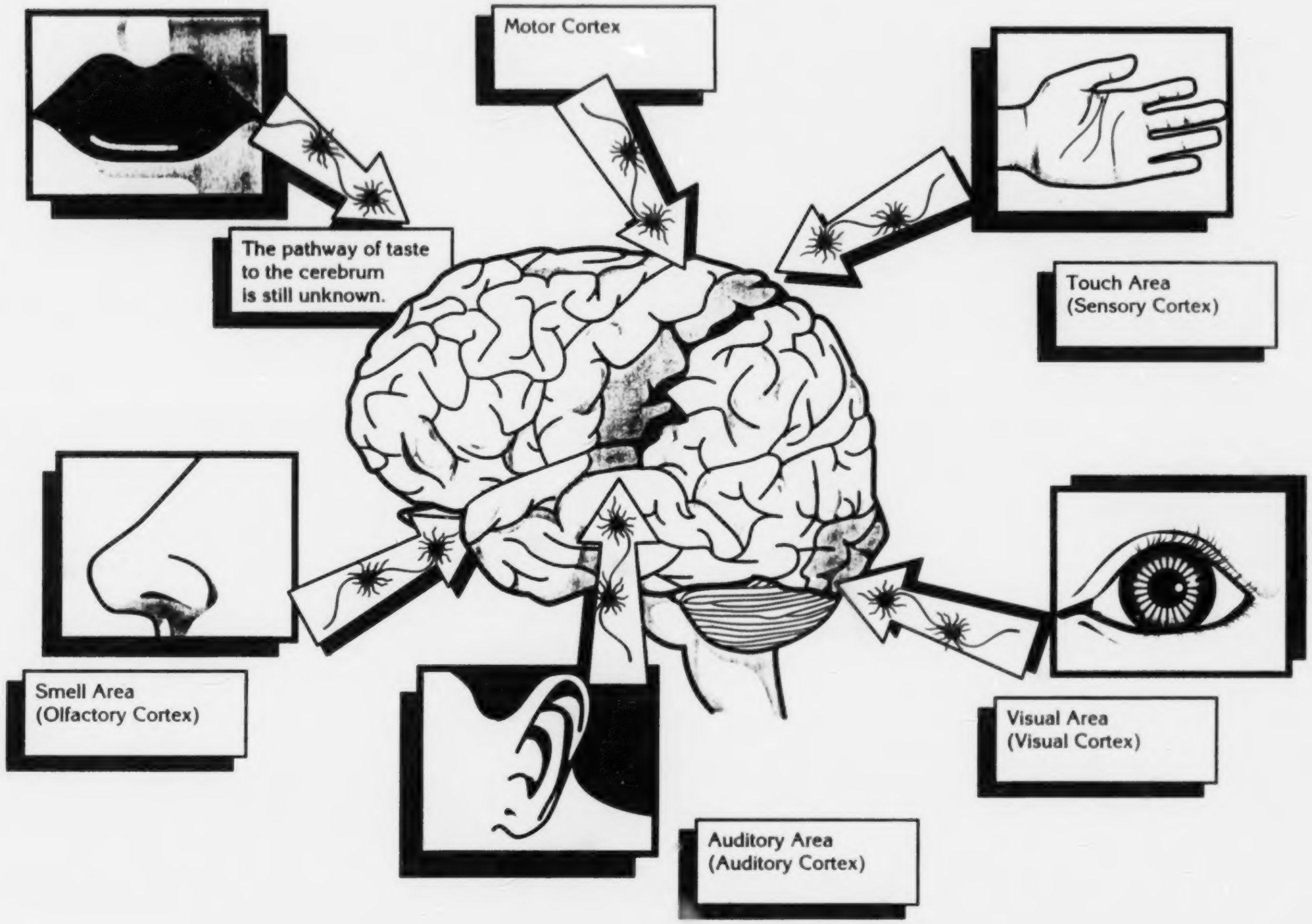
Sensory Areas of the Cerebrum


Motor Cortex
The pathway of taste to the cerebrum is still unknown.
Touch Area (Sensory Cortex)
Smell Area (Olfactory Cortex)
Visual Area (Visual Cortex)
Auditory Area (Auditory Cortex)

Information from each sense is processed in a different part of the cerebrum. Information from these areas is sent to other parts of the brain for further processing.

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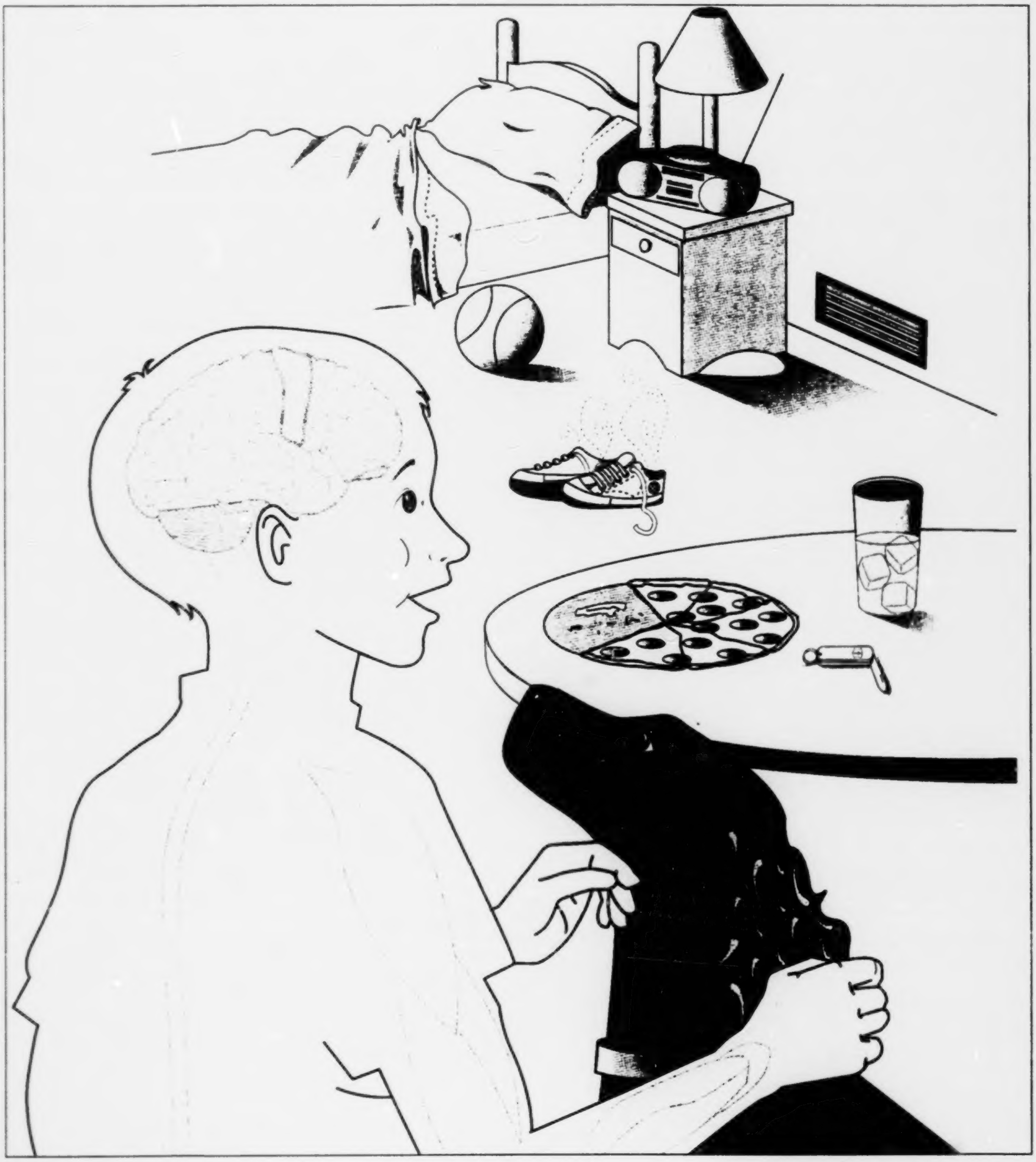
Sensory NeuroKid

There are many things in NeuroKid's room that he can see, hear, smell, taste or touch. Draw a line from some of these things to the place on his body (such as his eye, ear, nose, mouth or hand) where NeuroKid would receive information about them. Then connect the line to the place in NeuroKid's brain where that sensory information would go.



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SensePhone

BRAINLINK BACKGROUND (for the teacher)

Some *neurons* or other cells act as *receptors* to translate different types of physical information (light, heat, presence of certain molecules, etc.) into nervous system messages or signals. These signals then travel along *sensory neurons* to the brain.

Most sensory receptors are specialized to respond to a particular type of information. For example, there are different receptors in the skin devoted to receiving and transmitting information about pain, pressure, heat, cold and touch. Interestingly, there are many aspects of the physical environment to which our receptors do not respond. For example, we "see" light only between wavelengths of 400 and 700 nanometers (one nanometer is equivalent to one billionth of a meter) in the electromagnetic spectrum. Other organisms, such as many species of bees, are able to see wavelengths that are invisible to us.

The brain continually is being bombarded by sensory signals from inside our bodies and all around us. Incredibly, it is able to filter out much of that input, enabling us to ignore some of the signals, but to utilize others. Complex communication and processing occur continuously within the brain's neural networks to produce "understanding" of what is happening around us.

This activity is designed to help students discover, in a basic way, how the senses work together. It emphasizes the very important role the brain plays in deciphering and integrating sensory information.

LINKS

This activity may be taught along with the following components of the Sensory Signals unit.

***The Cookie Crumbles* chapters:**
- Decision Made
- Dark Voices
- Also see science boxes on pages 3-4

***Explorations*:**
- Gray Matters (page 2)
- Is Seeing Believing? (page 3)
- Sensible Games (page 5)

SET-UP

You will need to copy the What Would You Be Doing If...? pages and cut out the individual cards. Students may do this if you prefer. Divide the class into groups of six students to conduct this activity.

ACTIVITY 3

CONCEPTS

- The brain receives and integrates information from all of the senses.

OVERVIEW

Students create a string and cup model of sensory receptors and the brain that allows them to explore how the brain puts together information from each of the senses.

SCIENCE & MATH SKILLS

Using variables, measuring, modeling, problem solving and inferring

TIME

Preparation: 10 minutes
Class: 45-60 minutes

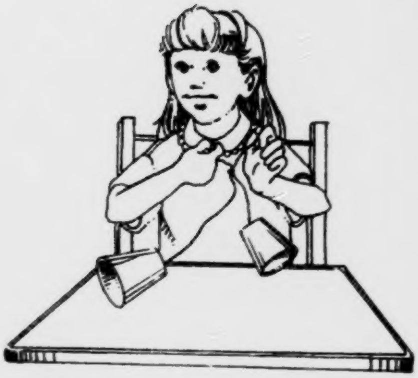
MATERIALS

Each group of six students will need:

- copy of "SensePhone Instructions" on page 10
- set of "What Would You Be Doing If...?" cards on pages 11-15
- 6 disposable cups (8 oz size)
- 15 m of medium weight cotton string
- 11 paper clips
- scissors
- colored pencils or markers

PROCEDURE

1. Have each group construct a sensory nervous system model consisting of 5 "sensory receptors" (cups) connected by separate "sensory neurons" (strings) to a central receiver or "brain" (cup) using the SensePhone Instructions as a guide. The string from each "receptor" will enter the "brain" at an area representing the specific area of cerebrum for that sense.
2. Use the SensePhones to learn about the brain's role in "making sense" of incoming information. Distribute a set of "What Would You Be Doing If...?" riddle cards among the "sensory receptors" in each group. Retain the answer cards for yourself. Cards for four riddles are provided. Students may enjoy creating their own riddles on the blank cards.
3. Within the groups, have each "sensory receptor" read his/her information in turn into the "receptor" cup so that only the "brain" can hear it. After listening to all of the clues, the "brain" should put all the information together (integrate it) in order to come up with a solution. Allow the "brain" a few moments for thinking after the clues are spoken.
4. There may be many "right answers" to each riddle. The answer cards contain one possible interpretation of the sensory information. Your students may be more creative at answering the question, "What Would You Be Doing If...?" Accept all answers that are plausible!
5. After the "brain" has proposed a solution, have each "receptor" read his or her information to the group. Ask the students, *Is the information from any of the individual senses enough to figure out the answer? Does the brain have enough information to solve the riddle?* Have students within each group rotate positions after each riddle.
6. Develop a class discussion about the senses and sensory integration by asking the students, *Do you think that you could describe an object using only one sense? If so, which sense? If not, which sense might give you the most information? What about describing a whole situation or activity? Why might you be able to describe an object, but not an activity, using only one or two senses?*



Students use cups and string to create a model of the sensory nervous system.

Distribute riddle cards to each group of students. Use the blank riddle cards on page 15, if students would like to create their own riddles.

BRAIN JOGGING

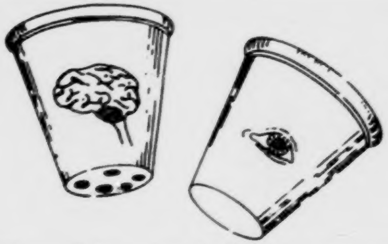
Here are more ideas for you and your students to explore.

- Think of situations in which information from only a single sense is not enough to understand what is happening.
- Why do you think the sensory receptors for hearing, seeing, smelling and tasting are located on your head?

If desired, students may experiment with different types of string, cups, attachment methods, lengths of string, indoor and outdoor settings, etc. to get the best results from their model.

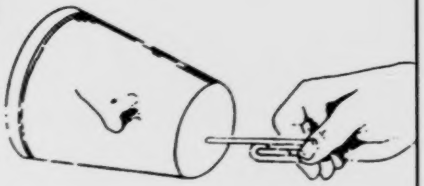
SensePhone Instructions

1



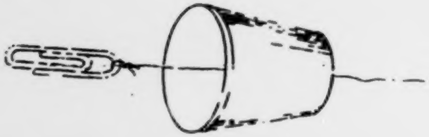
You will need six cups. Label one cup as the "brain." Make five dots around the bottom of the "brain" cup to represent the primary sensory areas. Put a label or a picture on the remaining five cups to represent eyes, ears, mouth, nose and skin. These cups will be the "receptors."

2



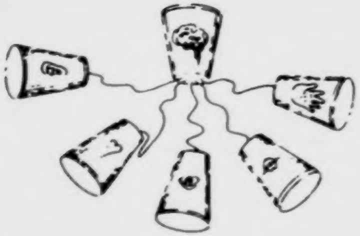
Carefully open a paper clip and use the end to make a small hole in the center of the bottom of each "receptor" cup. Also make a hole in each of the dots on the bottom of the "brain" cup.

3



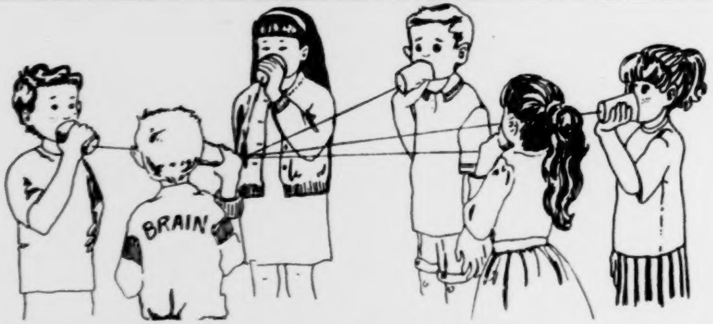
Measure and cut five pieces of string, each 2.5 m (8 ft) long. Push one end of each string through the hole in the bottom of each "receptor," and tie the string to a paper clip inside the cup to keep the string from pulling out of the hole.

4



Attach the "receptor" cups to the correct area of the "brain" cup by threading the "sensory neuron" string from each "receptor" through its matching "brain" area. Tie the strings to the ends of 5 paper clips inside the "brain" cup to keep the strings from pulling out.

5



Test your SensePhone.

- Brain: Hold the "brain" cup tightly against your ear and listen.
- Receptors: Hold the "receptor" cups over your mouths and take turns speaking clearly in low voices. "I am your ... [eyes, ears, nose, mouth, skin]." Be sure to keep the string tight while speaking.

BrainLink
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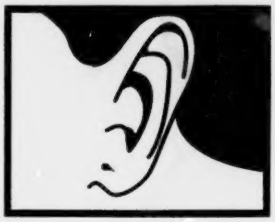
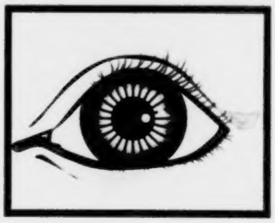
What Would You Be Doing If...?

Riddle 1



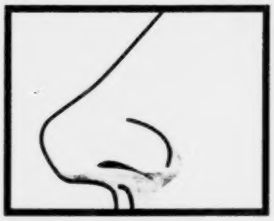
I hear something crunching.

Riddle 1



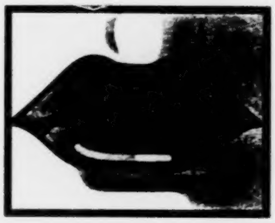
I see something red and round.

Riddle 1



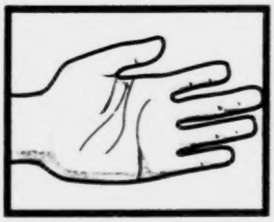
I smell something sweet.

Riddle 1



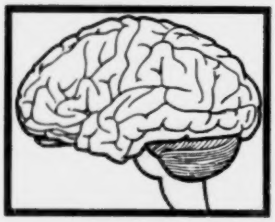
I taste something sweet and tart.

Riddle 1



I feel something hard and smooth.

Riddle 1



Possible brain solution:
I am eating a red apple.

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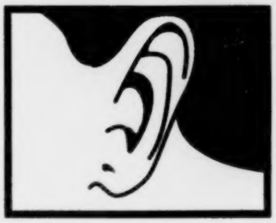
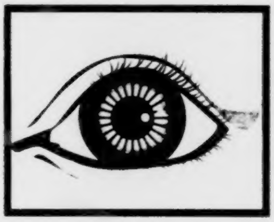
What Would You Be Doing If...?

Riddle 2



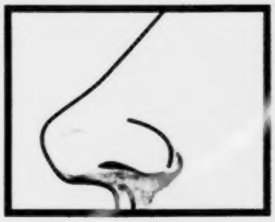
I hear something dripping.

Riddle 2



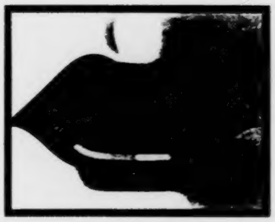
I see something rounded and yellow.

Riddle 2



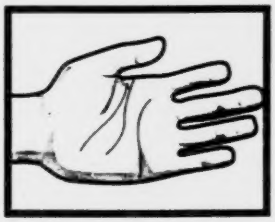
I smell something sharp and refreshing.

Riddle 2



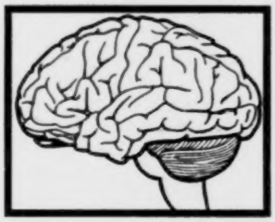
I taste something sour.

Riddle 2



I feel something slick and bumpy.

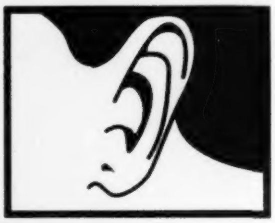
Riddle 2



Possible brain solution:
I am making lemonade.

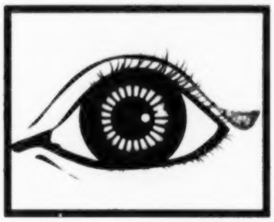
What Would You Be Doing If...?

Riddle 3



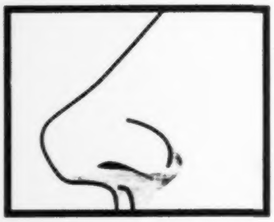
I hear wind blowing and water rushing.

Riddle 3



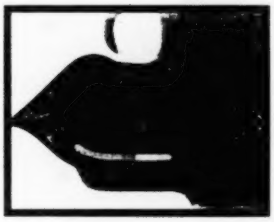
I see blue and white.

Riddle 3



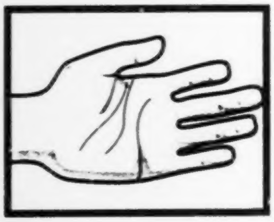
I smell something fishy.

Riddle 3



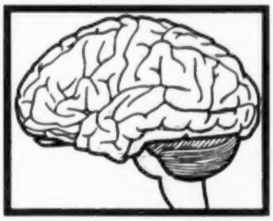
I taste something salty.

Riddle 3



I feel something wet.

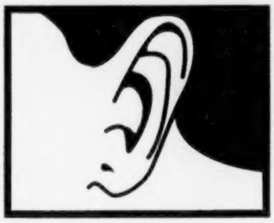
Riddle 3



Possible brain solution:
I am at the ocean shore or beach.

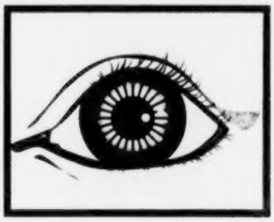
What Would You Be Doing If...?

Riddle 4



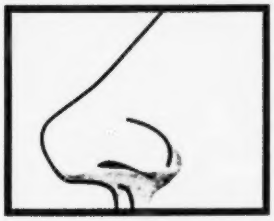
I hear crowd noises and music.

Riddle 4



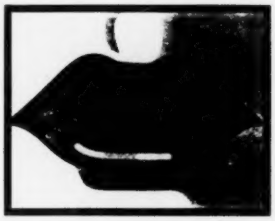
I see movement, colors and many people.

Riddle 4



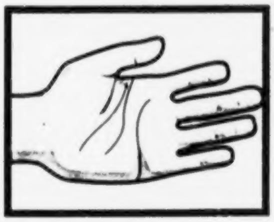
I smell popcorn and hot dogs.

Riddle 4



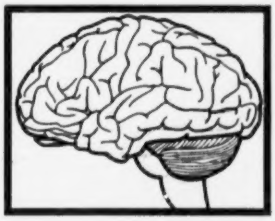
I taste something salty.

Riddle 4



I feel hot and dusty.

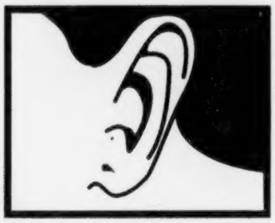
Riddle 4



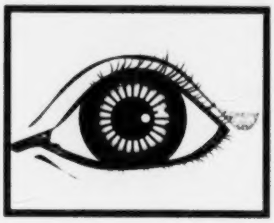
Possible brain solution:
I am at a rodeo, carnival or fair.

What Would You Be Doing If...?

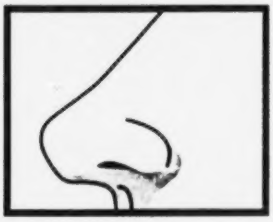
Blank Riddle Cards



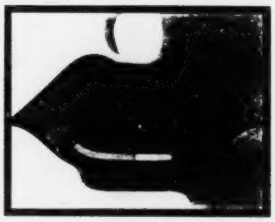
I hear:



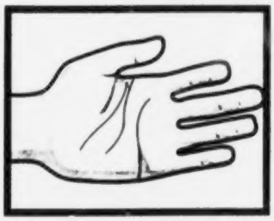
I see:



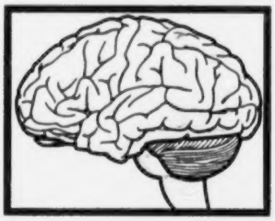
I smell:



I taste:



I feel:



Possible brain solution:

Vision and Illusions

ACTIVITY 4

BRAINLINK BACKGROUND (for the teacher)

The Visual System

Most of our knowledge about the surrounding world comes from the sense of vision. This seemingly miraculous sense transforms signals produced by light energy entering the eye into perceptions of movement, color and form. The abilities to recognize a face, identify an object under different conditions of light or interpret the different components of a landscape result from complex processes that take place in many different areas of the cerebral cortex. The strategies used by the brain in vision cannot be duplicated, even by the most sophisticated existing computers and software.

We only are beginning to understand how the visual system in the brain works. While it was once believed that vision worked like a simple camera, we now know that it is a much more complex process. Light enters the eye through the *pupil* and is focused by the lens on the *retina*, where it activates special light-sensitive cells (rods and cones). These cells convert light energy into electrical signals that travel along the optic nerve to the visual centers of the brain. The *primary visual cortex*, where signals are first processed, is located at the back of the head. However, there are at least 20 other areas of cerebral cortex devoted to the processing of visual information. Cells in different areas of the visual cortex respond to different characteristics of objects (for example, motion, form, color). Each of these areas receives special information carried along separate pathways. This information is assembled along parallel and hierarchical routes, not yet fully understood, to form a three dimensional mental perception of the world.

Tricking the Eye and Brain

Optical illusions provide clues about the ways in which the brain processes visual information. The brain appears to make certain assumptions about what is to be seen in the world. When insufficient information is provided or the information is conflicting, the brain can be "tricked."

In this activity, students will explore several well-known illusions. They are based upon the following principles.

CONCEPTS

- Some optical illusions provide clues about how the brain processes visual information.
- The brain can be fooled by insufficient or conflicting visual input.

OVERVIEW

Students learn about the brain's role in vision, as they experience well-known optical illusions.

SCIENCE & MATH SKILLS

Observing, identifying variables, identifying relationships and measuring

TIME

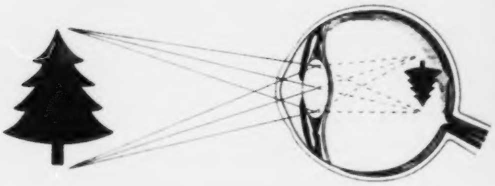
Preparation: 10 minutes
Class: 30-45 minutes

MATERIALS

- white notecards (one per student or pair of students)
- hand magnifiers (one per student or pair of students)
- copies of "The Vanishing Spot" and "Brain Illusions" on pages 21 and 22 (one copy per student)

Inverted Image

Light enters our eyes in the same way that it enters a pinhole camera or passes through a simple lens (such as a hand magnifier). As a result, the light that becomes focused on the retina presents an image that is inverted relative to the outside world. Higher levels of the brain adjust for this, so that we "see" the world in its correct orientation.

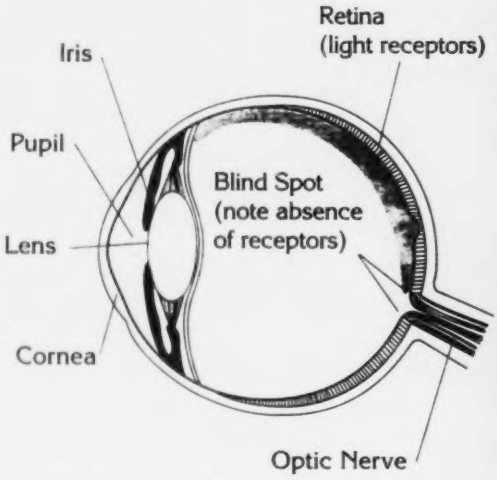


Images are inverted when they are focused on the retina.

Filling In

Sometimes, when information that the brain receives about the physical world is not complete, it tries to fill in the gaps. This happens with the area in the field of vision that corresponds to the "blind spot" on the retina. The blind spot is the exit point for the optic nerve to the brain. It contains no receptor cells and cannot react to incoming light.

However, we do not "see" a blank space in our field of vision, because the brain fills in the missing area with an estimate of what it should look like. This astonishing process can be experienced in the illusion presented on the student page, The Vanishing Spot. This illusion is constructed so that a black circle or a gap in a line falls exactly on the blind spot of the eye. When the brain "fills in" the blind spot, the image of the circle disappears and the line appears unbroken!



The blind spot has no receptors for light, yet we do not see a blank space in our field of vision.

Grouping

Light coming into the eye is detected as tiny points by the individual receptors in the retina. This information must be processed through many levels in the brain before it becomes useful. In fact, the association of separate points into more meaningful mental images is one of the primary tasks of the visual cortex. One of the ways the brain organizes visual information is by clustering objects that are close together. As a result of this tendency, the groups of dots in the second example on Brain Illusions appear to be arranged either in columns or in rows, depending upon the spacing.

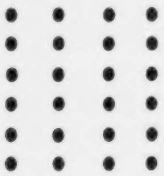


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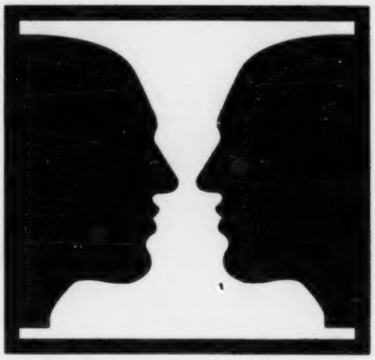
Figure vs. Ground

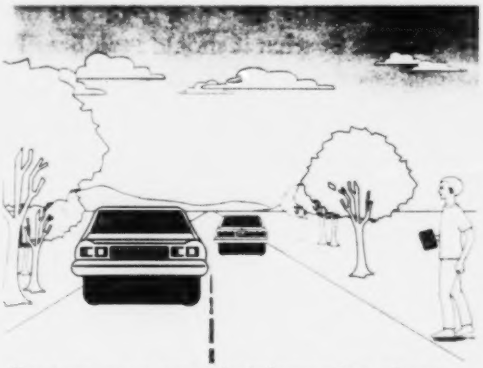


Do you see a vase or two profiles?

The visual system works on a "winner takes all" basis. The eye and brain can focus intently on only one object at a time. Everything else is reduced to background. When a figure is ambiguous, as in psychologist Edgar Rubin's famous vase example shown on the Brain Illusions page, the brain jumps from one interpretation to another. Thus, the figure can appear as either two faces in profile or a symmetrical vase, but not as both at the same time.

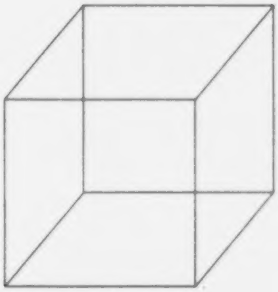
Context

One of the most difficult tasks faced by the brain is building a three-dimensional perception of the world from the two-dimensional image received on the retina. The brain uses several context clues to estimate depth and distance. One clue is shading. Look at the rows of circles in the third example on Brain Illusions. The circles will appear as spheres or cavities, depending upon where you assume the light is coming from. It is virtually impossible to see both rows of spheres as concave or convex (adapted from Ramachandran, V. 1988. Perceiving Shape from Shading. Scientific American 259(2):76-83). Another clue is perspective. Small-appearing or closely positioned objects can be interpreted as being far away, depending upon the relative size or distance of surrounding objects. Examples include railroad tracks that converge in the distance, or an automobile that gradually increases in size as it approaches. The brain uses clues about the relative size of nearby objects to interpret these examples correctly.



Context cues provide information about distance and size.

When provided with insufficient or conflicting information, the brain can be fooled. The open cube provided on the Brain Illusions page is a good example of this. Since there are no clues about which surface is closest to the viewer, the brain will switch among different interpretations of the cube. (This illusion was first devised by L. A. Necker in 1832.)



The Necker Cube is a well-known optical illusion.

LINKS

This activity can be taught along with the following sections of other components of the Sensory Signals unit.

***The Cookie Crumbles* chapters:**
- A Sensory Plan
- Everyone Needs a Brain
- Also see science box on page 19

***Explorations*:**
- Is Seeing Believing (page 3)
- Use Your Brain - Promote Your Health (page 4)
- Sensible Games (pages 5-6)
- The Neuro Side (page 6)
- Toad Hunt (page 8)

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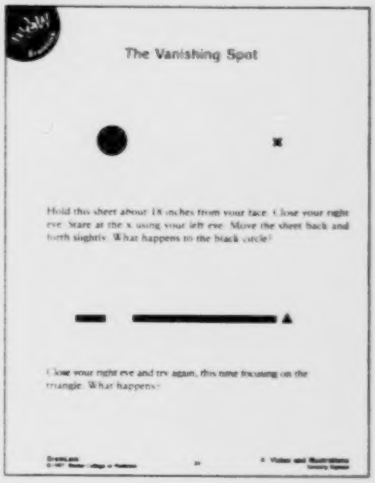
SET-UP

Conduct the following explorations in one longer or several short sessions, depending on the ages of your students and the time available. Students may work individually or in pairs.

PROCEDURE

1. **Inverted Image.** Give a hand magnifier and a note card to each student or pair of students. Direct them to stand with their backs to a window as they hold the magnifiers a few inches in front of the note cards. The students should observe the image that is projected onto the card. (If the image is not sharp, have them move the magnifier forward and backward until it becomes focused.) Ask, *What do you see? Is it right side up?* Help the students understand that the image projected onto the retina of the eye also is inverted. The brain "flips" the image to its correct orientation as it builds a mental picture of the physical world.

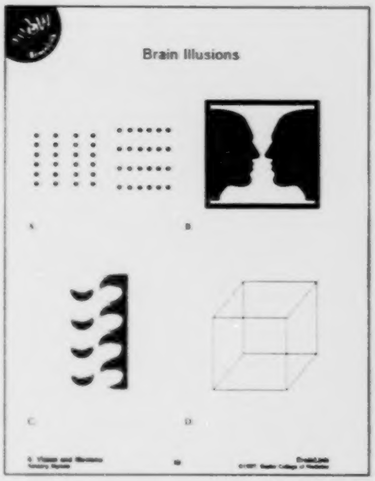
2. **Filling In.** Pass out copies of The Vanishing Spot and direct each student to follow the simple instructions listed at the bottom of the page. *What happens to the black circle? To the space in the black line? What do you think is happening?* Lead the students to conclude that the brain is filling in the space corresponding to the "blind spot" on the retina.


The Vanishing Spot

Hold this sheet about 18 inches from your face. Close your right eye. Stare at the x using your left eye. Move the sheet back and forth slightly. What happens to the black circle?

Close your right eye and try again, this time focusing on the triangle. What happens?

3. **Grouping.** Give each student a copy of Brain Illusions. Ask students to focus their attention on the rows of dots shown in example A. First, ask them to establish the number of dots in each group. Follow by asking, *Are the dots in the first group arranged cross-wise or up-and-down? Why do you think so? What about the dots in the second group?* Lead the students in a discussion about the role of spacing in altering their perceptions of the arrangement of the dots.


Brain Illusions

4. **Figure vs. Ground.** Let the students look at example B on the Brain Illusions page. Ask them to describe what they are seeing. (Some will see a vase, others a pair of faces, and others may mention that the image switches between the faces and the vase.) Encourage the students to think about what might be happening. Explain that the eye and brain can be busy with only one object or image at a time and that everything else becomes background. In the case of this illusion, the brain jumps from one interpretation of the figure to the other. Follow by asking whether it is ever possible to watch two different things closely at the same time.

5. **Context Clues.** Direct students' attention to example C. Ask them to imagine that the light illuminating the spheres is coming from above. Have them identify which row of

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spheres looks like it is concave and which row looks convex. Now, ask them to mentally switch the light source to below the figure. *Which row is concave and which is convex now?* Challenge the students to establish whether it is possible to see both rows simultaneously as concave or convex. *Why or why not?*

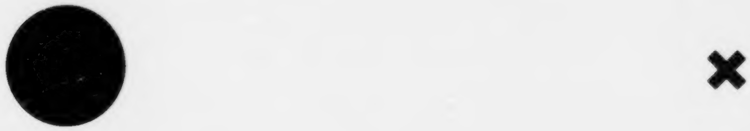
6. Challenge students to identify which side of the open cube in example D is facing forward. *Is it possible to tell? What kinds of clues would we need to determine which side is closest to the viewer?* Students also may notice that their attention will flip between two (or more) different interpretations of the cube, much in the same way as their interpretation of example B switched between the vase and the two faces.

BRAIN JOGGING

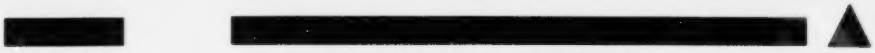
Here are more ideas for you and your students to explore.

- Try using different tricks of perspective to create drawings that represent three-dimensional objects or scenes. Possible techniques include using shading, making background objects smaller, and letting linear objects converge in the background.
- Find other examples of illusions, and ask students to describe what they think the brain is doing (filling in, using context clues, etc.). Be aware that the brain mechanisms behind some illusions still are not understood.

The Vanishing Spot

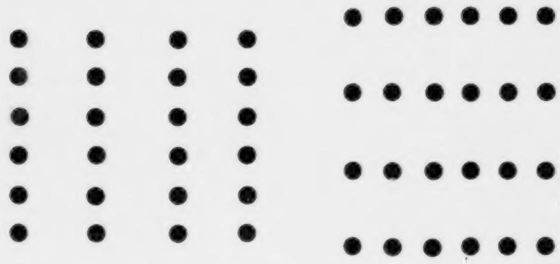


Hold this sheet about 18 inches from your face. Close your right eye. Stare at the x using your left eye. Move the sheet back and forth slightly. What happens to the black circle?

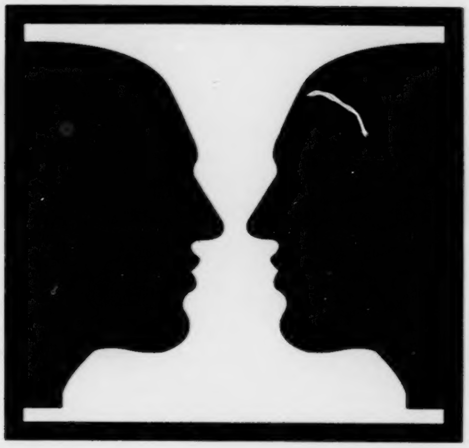


Close your right eye and try again, this time focusing on the triangle. What happens?

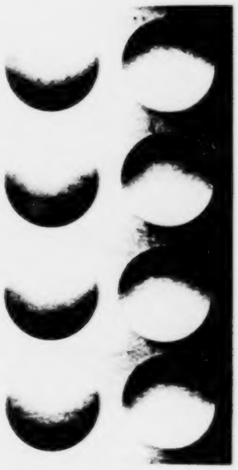
Brain Illusions



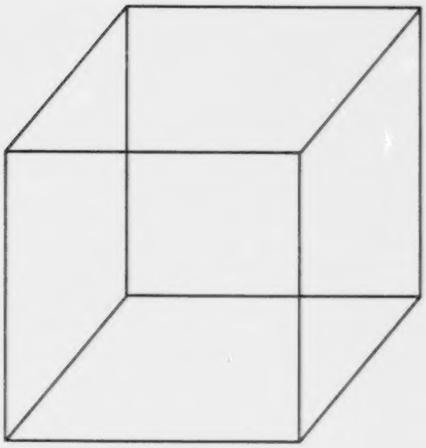
A.



B.



C.



D.

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Can You Hear Me?

BRAINLINK BACKGROUND (for the teacher)

Hearing and the Ear

Sound is produced when an object vibrates in air (or another medium, such as water) and produces alternating bands of high and low pressure, known as sound waves. Even though sound waves possess very low levels of energy, our ears and brain are able to detect the frequency and loudness of sounds, as well as to locate sound sources.

The human ear is designed to collect sound waves and detect minute changes in air pressure. The outer ear consists of the ear flap and a short passageway known as the *auditory canal*. The *eardrum* or tympanic membrane is located at the inner end of the auditory canal. The eardrum bulges inward or outward in response to pressure changes caused by sound waves. This movement is amplified by the three tiny, interconnected bones residing in the *middle ear*.

Another membrane separates the middle and inner ears. The inner ear is a complicated labyrinth of interconnected fluid-filled chambers and canals. The upper group of canals is important for the sense of balance. The lower canal is coiled like a snail shell and is filled with fluid. This structure, known as the *cochlea*, converts pressure waves into impulses that are sent along sensory neurons to the auditory centers in the brain.

Sensory Loss

Our ability to detect and process information from the outside world depends on the presence of intact and functioning sensory systems. Whenever any of the components of a particular sense is harmed, our capacity to receive information through that sense may be diminished, distorted or eliminated. In the ear, damage to any of the parts described in the preceding section could result in partial or complete hearing loss.

Some kinds of sensory loss are preventable! While we are not able to protect our sensory systems from every kind of damage, certain measures can be taken to limit harmful situations. This is particularly true of the sense of hearing. Simple actions, such as wearing earplugs in noisy settings, often can prevent damage to delicate structures inside the ear. In addition, protective headgear and helmets for sports and certain occupations help avoid serious head injuries. Safety glasses, shaded lenses, heavy gloves, protective clothing, and sun screens all shield valuable sensory receptors in the eyes and skin.

This activity lets children experience how earplugs reduce the amount of sound that enters the ear.

ACTIVITY 5

CONCEPTS

- The human ear is designed to trap sound waves and convert information about sound into nervous system signals.
- Some kinds of hearing loss are preventable.

OVERVIEW

Students experience the effects of ear plugs and learn about protecting the ear, as an example of how sensory loss can be prevented.

SCIENCE & MATH SKILLS

Observing, considering and calculating variables, measuring and drawing conclusions

TIME

Preparation: 15 minutes
Class: 30 minutes

MATERIALS

- copies of "How Loud Is Too Loud?" on page 26
- disposable earplugs (one pair per student)
- cassette/compact disc player and one or more tapes or compact discs

Protect Your Hearing

Headphones are a particularly insidious contributor to hearing damage. If the volume on a personal tape player is so loud that another person can hear the sound coming from the headset, the wearer may be harming his/her ears!

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LINKS

This activity may be taught along with the following components of the Sensory Signals unit:

***The Cookie Crumbles* chapters:**
- Bittersweet
- Visible Clues

***Explorations*:**
- Gray Matters (page 2)
- Decade of the Brain (page 4)
- Sensible Games (page 5)

SET-UP

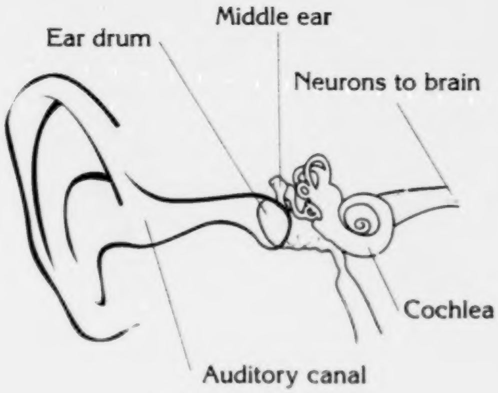
This activity may be carried out with the entire class or with groups of three students. In either case, the activity requires three different categories of participants: (1) students with earplugs, (2) students without earplugs and (3) observers, who also will act as recorders.

In advance, select one or more cassette tapes, CD's or radio settings that present different kinds of sounds. Examples include speaking voices, vocal music, classical instrumental music, special sound effects, rock music, etc. For each trial with the students, gradually increase the volume of the cassette or CD player from the lowest setting possible to one that is between medium and high (the actual amount that you increase the loudness will depend on your classroom size and other factors). If possible, have students sit in a circle, all at an equal distance from the sound source.

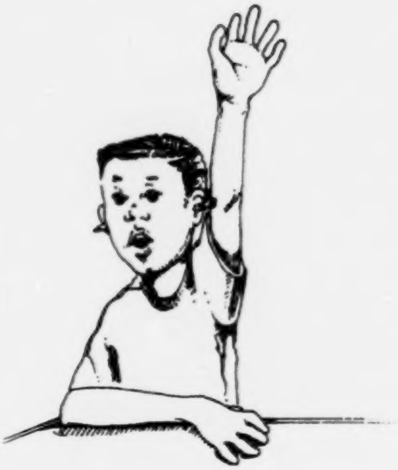
You or some of your students may want to prepare a tape of different sounds to use for this activity.

PROCEDURE

1. After dividing them into groups, explain to students that they will be listening to sounds that will increase gradually in loudness. Tell the students in the "earplugs" and "without earplugs" groups to keep their eyes closed during the experiment and raise their hands when they first begin to hear a sound. When they stop hearing the sound, they should lower their hands and wait for the next one. Repeat the experiment several times with different kinds of music or sounds. The "observers" should record which of the other two groups responded to the sound first during each trial. Depending on the age of your students, you may wish to have them record the actual time intervals between the responses of each group.



The ear is designed to capture sound waves and transform them into impulses that can be sent along sensory neurons to the brain.



Students should raise their hands when they first begin to hear the sound.

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2. Have all the "earplugs" participants insert the plugs gently into their ears. The plugs should fit snugly, but not be uncomfortable.

3. Play each sound, gradually increasing the volume until all or most of the students have raised their hands. Repeat the experiment several times with different kinds of music or sounds. The "observers" should record which of the other two groups responded to the sound first during each trial. You may wish to have students calculate the actual time intervals between responses by the two groups.

4. Lead a discussion of the results of the trials. You may do this informally, or you may wish to tabulate the observations on the board. *Did the students wearing earplugs first hear the sound at lower or higher levels of loudness than the group without earplugs? What does this tell us, in general, about the usefulness of earplugs? For which types of sounds were the earplugs most effective?* Discuss the information presented on the How Loud is Too Loud? sheet.

BRAIN JOGGING

Here are more ideas for you and your students to explore.

- Imagine a new invention that could help compensate for the loss of one of the senses or that increases the acuity of a sense. Describe your sense-improvement invention in a short paragraph or story, or draw a picture of it.

- Use the SensePhones to investigate the consequences of damage to different components of the sensory system. Have different groups simulate "damage" to receptors, sensory neurons or the brain by cutting or otherwise modifying the corresponding component of the SensePhone (i.e., receptor cups, string or brain cup) and testing whether a message can be sent.

- Individuals who are deprived of a particular sense (vision, hearing, etc.) often learn to rely more on information obtainable through other senses. Common examples include the use of vision by deaf persons to "read" lips and understand spoken language, or the use of touch in the fingertips by blind persons to "read" Braille texts. Such individuals usually are able to live rewarding and productive lives by substituting input from one sense with that from another sense. Can you think of other examples of sense substitution?

Sensory Loss

Sensory loss can occur as a result of disease or damage to any of the parts of the sensory system, as described below.

- ***Sensory receptors*** (in the eye, ear, skin, etc.). Damage to sensory receptors can take place in small increments over time, or can result from a sudden catastrophe. Hearing loss from repeated exposure to loud noise is an example of the effect of gradual injury to sensory receptors. Severe blows to the eye or ear can cause permanent blindness or deafness by harming one or more of the delicate parts. Extremely loud noises also can cause immediate and irreversible hearing loss.

- ***Sensory neurons.*** When the neurons that carry sensory information to the brain degenerate or are severed, no signal will reach the appropriate area of the brain, even if the sensory receptor remains intact. Multiple sclerosis is an example of a disease that can lead to loss of the sense of touch and/or vision through the gradual breakdown of the myelin sheath protecting some sensory neurons. In the case of hearing, damage to the nerves between the ear and the brain will result in deafness.

- ***Brain.*** Sensory loss as a result of brain damage depends on the region of the brain that is affected. Specific injury to a very small area of the cerebrum can impact only one sense. However, swelling and other secondary consequences often lead to ill effects in many areas of the brain.

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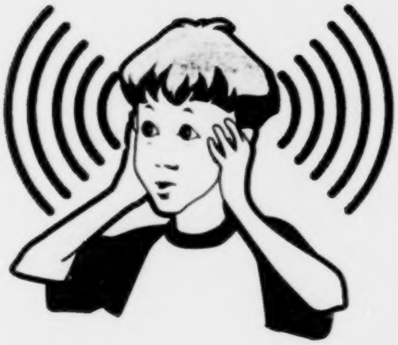
How Loud Is TOO Loud?

Ringing or a full feeling in the ear signals that you are being exposed to noise that could be harmful. When this happens, let your ears rest in a quiet place!

Remember, loud noises are dangerous! Sounds in the DANGER ZONE can cause hearing loss if exposure continues for too long a time. Sounds at 140 decibels or higher can even cause instant damage to hearing.



Sound is measured in units called decibels (db). See how different types of sound compare.

DANGER ZONE

Sound Units (db)	
140	firecrackers, jet engine, gun shot
130	rock concert
120	headphones, car stereo
100	snowmobile, subway train
90	city traffic, lawn mower, motorcycle
80	alarm clock, hair dryer, factory
70	restaurant, vacuum cleaner
60	normal conversation
50	average home, refrigerator
40	principal's office
30	soft whisper, quiet library

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Tactile Tests

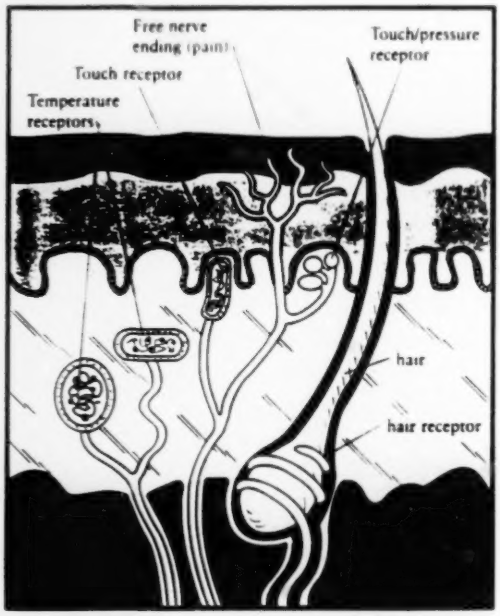
ACTIVITY 6

BRAINLINK BACKGROUND (for the teacher)

We often speak of the five senses: *vision, hearing, taste, smell and touch*. However, the tactile sense, traditionally called "touch," actually encompasses a large group of more or less separate senses. These include pressure, vibration, warmth, cold, heat and pain, detected in the skin and deeper tissues.

The number of different kinds of receptors, or "sensors," present in the skin and the ways in which different dimensions of touch or feeling are detected by those receptors are not completely known. We do know that pressure receptors at the base of each hair detect minute movements that correspond to contact, or being touched. Other specialized receptors register temperature. Pain is detected by free nerve endings.

The perception of different feelings is not distributed equally in the skin. For example, in any given area, there usually are more points that are sensitive to pain than there are points that are sensitive to pressure or to temperature. In addition, some areas of the body have more sensory receptors of a particular kind than others. For example, there are more pressure-sensitive



Cross Section of Skin

(Note: Characteristics of skin without hair and skin with hair are combined for purposes of illustration.)

CONCEPTS

- The ability to discriminate between objects by using the sense of touch varies on different parts of the body.

OVERVIEW

Students explore the sense of touch by comparing skin sensitivities on the upper arm and fingertips.

SCIENCE & MATH SKILLS

Observing, comparing, drawing conclusions

TIME

Preparation: 15 minutes
Class: 30 minutes

MATERIALS

- 12 paper lunch bags
- pairs of similar materials that can be discriminated by touch (different grits of sandpaper, washer and a coin, rabbit or synthetic fur and cotton balls or fluff, smooth and rough fabric, smooth and rough cardboard, newsprint and copier paper, aluminum foil and waxed paper, etc.)

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receptors on the tip of the tongue and on the fingertips than anywhere else in the body.

This exploration allows students to compare the relative sensitivity of skin on different parts of their bodies (upper arm and fingertips). By trying to feel the difference between two similar objects having slightly dissimilar textures, students discover that some areas are more sensitive than others. This is because there are more sensory receptors for touch in some places than in others.

LINKS

This activity may be taught along with the following components of the Sensory Signals unit:

The Cookie Crumbles chapters:
  Making Sense?
  Feeling for Clues (see science box on page 23)
Explorations:
  Cover activity
  Gray Matters (page 2)
  Careers for NeuroExplorers (page 7)

SET-UP

Prior to class, place similar pairs of objects in numbered brown paper lunch bags. (Suggestions for pairs of objects are listed in materials.) You will need one bag for each two students.

Conduct this activity with students working in pairs.

PROCEDURE

1. Distribute one of the bags you have prepared to each pair of students. Have one student in each pair close his/her eyes. Ask the remaining student to remove the objects from the bag and gently rub them, one at at time, on the upper arm of the student with closed eyes. Can he or she feel any difference between the two objects?

2. Then have the teams test the same two objects on the fingertips of the students with closed eyes. *Are they able to feel a difference this time?* Ask them to describe the two things they felt.

3. Rotate the bags among groups, have the students trade jobs and repeat the process as time allows.

Try This!

Many of the sensations that we feel consist of blends of information from different kinds of receptors in the skin. For example, the feeling of wetness is generated by the simultaneous stimulation of receptors for cold and pressure.

To convince yourself of this, cover your finger with clear plastic and then place it in cold water. It will feel wet!

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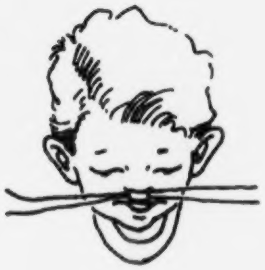
4. Use these class discoveries along with the information in BRAINLINK BACKGROUND to lead a discussion about differences in skin sensitivity among body areas. Help students understand by asking questions such as, *Could you tell whether objects were the same or different with your fingers? With your arm? From which area of the body do you think the brain gets more sensory information? In which area are there more sensory receptors? Why do you think the hands are more sensitive?*



Try creating long whiskers such as those of a cat.

BRAIN JOGGING

Here are more ideas for you and your students to explore.

- Try taping "whiskers" (straws, pipe cleaners, etc.) onto your cheeks. Imagine that you are a cat or other animal that navigates in the dark. Would your "whiskers" help you judge the nearness of objects or the size of openings? How could you find out? Do you think the hairs on your body improve your sense of touch?
- Why do you think it is important for our skin to contain sensory receptors for heat, cold and pain in addition to those for simple "touch" (contact, pressure)? Do you suppose there are more receptors in the skin for pressure or for pain?

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Get the Point?

ACTIVITY 7

CONCEPTS

- Sensations in the skin are detected by special receptors.
- Each receptor in the skin receives information from an area known as its receptive field.
- Some parts of the body have more receptors in the skin than others.

OVERVIEW

Students experiment to discover differences in the sizes of "touch" receptive fields in their inner arms, palms and fingertips.

SCIENCE & MATH SKILLS

Predicting, measuring, gathering data, comparing and drawing conclusions

TIME

Preparation: 10 minutes
Class: 45 minutes

MATERIALS

- rulers (one per group)
- paper clips (two per group)
- tape
- copies of "Get the Point?" on page 32 (one per group)

BRAINLINK BACKGROUND (for the teacher)

The area of skin from which a sensory receptor receives information is called its receptive field. In a part of the body with more receptors or nerve endings, the receptive fields are smaller because the receptors are closer together. For instance, there are many more sensory receptors in our fingertips than in the upper arm or leg. As a result, the receptive fields are smaller on the fingers than on the arm. You might make the analogy that there are "more dots per square inch" in the skin on our fingertips than in the skin on the upper arm. This makes it possible for the fingers to make finer discriminations of texture or minute objects than the upper arm.

This activity will allow students to experience and quantify the approximate sizes of receptive fields on their fingers, palms and upper arms.

LINKS

This activity may be taught along with the following components of the Sensory Signals unit:

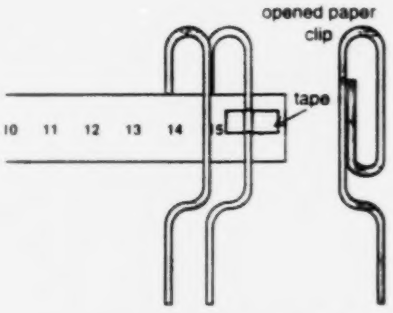
The Cookie Crumbles chapters:
Sensing Danger
The Better to Hear You With
Also see science box on page 23
Explorations:
Cover activity
Gray Matters (page 2)

SET-UP

To conduct this activity, divide the class into pairs of students.

PROCEDURE

1. Help each team create a testing tool by attaching two paper clips to a thin ruler as shown. One paper clip is taped in place and remains fixed. The other is moved along the ruler to create different distances between the points for testing. Each time the distance is set, the tips must be tapped on a flat surface to make them even.
2. Give each pair a Get The Point? data sheet. Diagrams at the top of the sheet illustrate points on the body to be tested (fingertip, palm of hand and forearm) and the amount of tip separation for each trial. Space is provided on the sheet for both students to record their results.



Two-point testing tool

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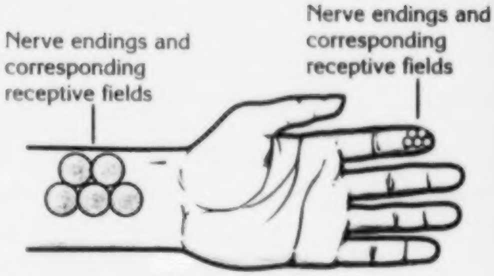
3. Each team should test all three points shown on the hand and arm at all four tip separation distances. For each test:
    - One student looks away and closes his/her eyes.
    - The other student sets the distance between the paper clips as shown on the Get The Point? sheet and gently touches the first student at the indicated touch point. NOTE: It is important that both paper clip ends touch the skin at the same time and with the same pressure.
    - The first student, whose eyes are closed, says "one" or "two" depending on whether he/she felt one or two points. Tell students they will not always be able to feel two points.
    - The other student writes a "1" or a "2" in the appropriate column on the Get The Point? data sheet. If the student being tested is not sure, the answer should be recorded as "1."
4. After the tests have been completed based on one student's responses, the experiment should be repeated with the other student.
5. Summarize data for the whole class by tallying student observations on the board. Have students compare results for the three test points. Conduct a discussion about differences in skin sensitivities among body areas. Help students to understand by asking questions such as, *How far apart did the points have to be before they felt like two points on your arm? On your palm? On your fingertip? Were there differences between you and your partner? Were there large differences in the class? Which of these three parts of your body must have the highest density of touch receptors? Which has the lowest density of touch receptors? Do you think that you can estimate the sizes of the receptive fields on your fingers, palm and upper arm?*


Nerve endings and corresponding receptive fields
Nerve endings and corresponding receptive fields

Comparison of receptive fields for touch in the finger and forearm.

Amazing!

We feel only one pressure point (even though the testing tool has two) when both points fall within the same receptive field.

Encourage students to keep an open mind as they experience this remarkable phenomenon.

BRAIN JOGGING

Here is another idea for you and your students to explore.

Do you think that you have many or few sensory receptors in your nose? ears? back? thigh? scalp? sole of foot? elbow? knee? Try the two-point test on these or other parts of your body, if you wish. Why do you think it might be advantageous to have more receptors in one area than another?

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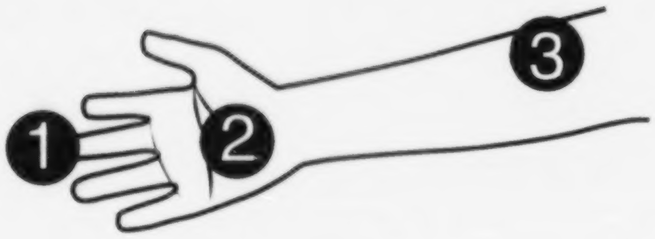
Get the Point?

TEST POINTS



TIP SEPARATION

5 mm ● ●
10 mm ●   ●
15 mm ●   ●
20 mm ●   ●

	TIP SEPARATION			
How many points do you feel?	5 mm 1 or 2?	10 mm 1 or 2?	15 mm 1 or 2?	20 mm 1 or 2?
1. FINGER TIP				
Name ______				
Name ______				
2. PALM				
Name ______				
Name ______				
3. INNER ARM				
Name ______				
Name ______				

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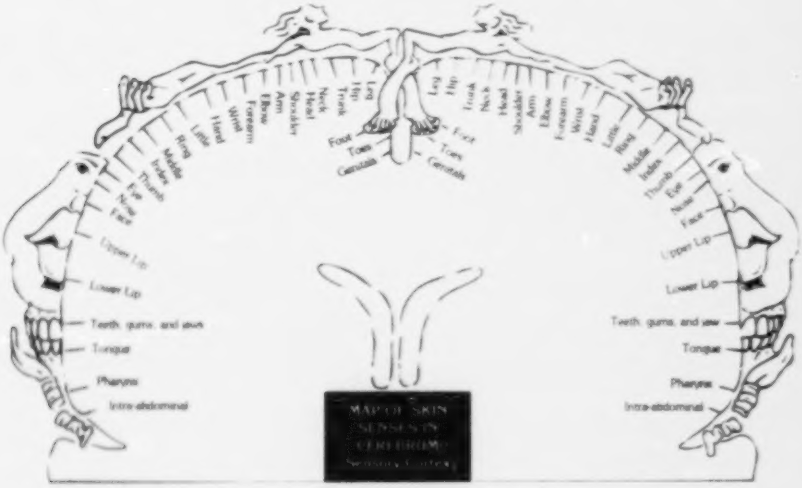
My Sensory Strip

BRAINLINK BACKGROUND (for the teacher)

A special part of the cerebrum, known as the *sensory cortex*, receives input only from the skin senses. This area lies right behind the motor cortex (see drawing on page 4). The size of the cerebral area that receives information from each region of the body depends upon how many sensory receptors the particular body area contains. In other words, areas of the body with many sensory receptors (like the fingers and lips) have much larger areas of cerebrum devoted to them than areas of the body with fewer receptors (like the legs).

In this activity, students will construct a "headband" that shows the relative sizes and approximate positions of the main areas of the body represented on the sensory cortex. They will compare the lengths of areas on the sensory cortex corresponding to different parts of the body, and combine that knowledge with information from the previous activity about the sensitivity of the upper arm, palm and fingertips.


Leg
Hip
Trunk
Neck
Head
Shoulder
Arm
Elbow
Forearm
Wrist
Hand
Little
Ring
Middle
Index
Thumb
Eye
Nose
Face
Upper Lip
Lower Lip
Teeth, gums, and jaw
Tongue
Pharynx
Intra-abdominal
Foot
Toes
Genitals
MAP OF SKIN SENSES IN CEREBRUM
Sensory Cortex

Adapted with permission from Kandel, Schwartz & Jessell, Principles of Neural Science, Edition 3, Appleton & Lange, 1991.

LINKS

This activity may be taught along with the following components of the Sensory Signals unit:

***The Cookie Crumbles* chapters:**
Putting It All Together
Caught in a Web
Big Trouble
***Explorations*:**
Gray Matters (page 2)

ACTIVITY 8

CONCEPTS

- A special part of the cerebrum—the sensory cortex—receives input from the body surface.
- Areas of the body that are important for the sense of touch have a larger representation on the sensory cortex.

OVERVIEW

Students make a model of the sensory cortex that they can wear, and they investigate which parts of the body correspond to the largest areas on the sensory cortex.

SCIENCE & MATH SKILLS

Predicting, measuring, interpreting data and drawing conclusions

TIME

Preparation: 5 minutes
Class: 45 minutes

MATERIALS

- copies of "Sensory Strip" on page 35 (one per student)
- pipe cleaners (one per student)
- rulers divided into millimeters
- scissors

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SET-UP

Divide the class into small groups of 2-4 students to share materials. Each student will make a Sensory Strip.

PROCEDURE

1. Tell students that they are going to create a model of the sensory cortex—the part of the brain that receives information about the sense of touch. If they already have created Motor Strips as described in the BrainLink Motor Highways unit, mention that the sensory cortex is similar to the motor cortex. In fact, it sits directly behind the motor cortex across the top of the brain.

2. Have the materials managers pick up copies of the Sensory Strip page, pipe cleaners and clear tape or glue for all members of their groups.

3. Explain that the areas marked on the Sensory Strip represent the approximate lengths of sensory cortex dedicated to information from the skin on different parts of the body. Larger areas of the sensory cortex correspond to regions of the body that have more receptors per unit area. Relate this information to the students' discovery about the sizes of receptive fields in the skin in Activity 7: Get the Point?.

4. Have students measure the lengths of areas in the Sensory Cortex strip corresponding to the upper arm, palm (hand) and fingertips. Write the numbers on the board or make a bar graph to compare them. Ask, *Which area is longer?* Next, have them use their Get the Point data sheets. Ask, *Which part had the smallest receptive fields (and, thus, the most receptors)? Which part had the largest receptive fields (fewest receptors)?* Relate this information to the measurements that they have made.

5. Let students make their strips by following the instructions on the Sensory Strip page.

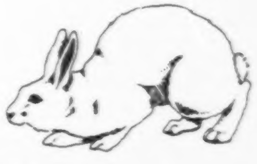
Sensory Strip

Students will make Sensory Strips that demonstrate approximate regions of the brain where touch information is first processed from different parts of the body.

BRAIN JOGGING

Here is another idea for you and your students to explore.

Like humans, other mammals have more sensory receptors for touch in certain parts of their bodies than in others. They also have correspondingly more cerebrum devoted to receiving input from the areas with more sensors. Based on their lifestyles, try to deduce which body areas might occupy more of the sensory cortex in the following animals: rabbit, monkey, horse, cat.


Animals also have more sensory receptors in some parts of their bodies than in others.

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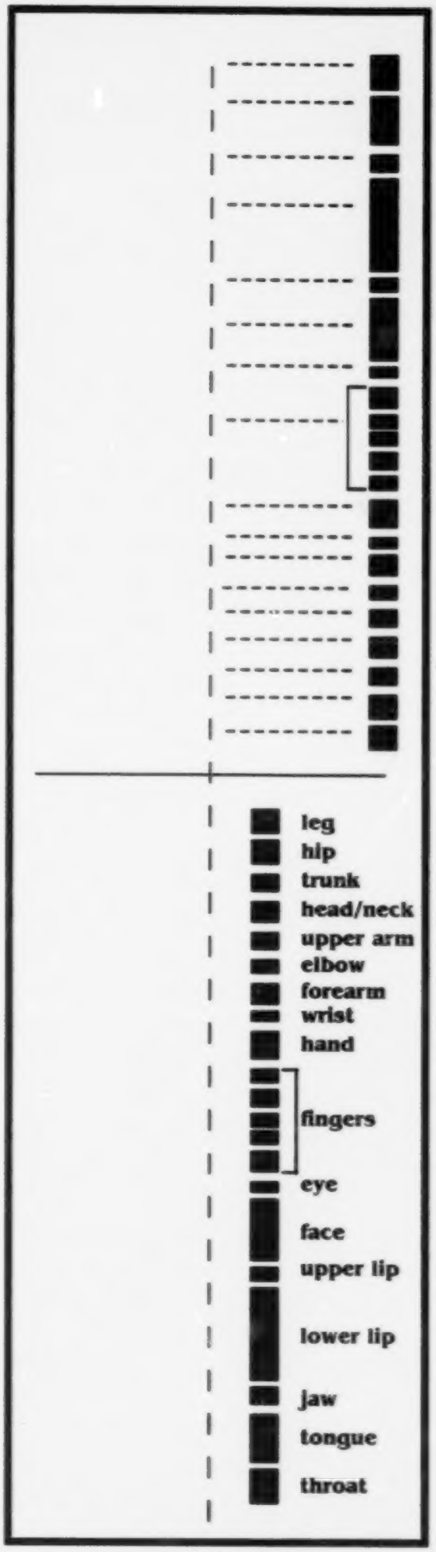
Sensory Strip

The sensory cortex is a thin strip of nerve cells that sits across the top of the brain about where you would wear a set of headphones. It lies just behind the motor cortex. Different parts of the sensory cortex receive information from touch receptors in different areas of the body.

You can see where the sensory cortex of your brain is located by making a Sensory Strip that you can wear. Each area of the strip will sit about where information from that part of the body is processed in your brain.

1. Cut out the large rectangle on this page.
2. Observe the labels on one side of the strip. Write in the names for each area on the other side of the strip, using the labeled side as a guide. Start at the midpoint. Both sides should be exactly the same.
3. Fold the rectangle along the dotted line.
4. Put a pipe cleaner inside the folded rectangle, and close the edges of the sheet with glue or tape.
5. Bend the strip into a U-shape like a headband or headphones, and try it on.

Can you find about where your brain receives touch information from your fingers? Can you find where your brain receives information from your wrist? Which area takes up more space on the sensory cortex? Why do you think that this is so?



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Use Your Brains, Create Refrains

ACTIVITY 9

CONCEPTS

- Concepts presented in preceding activities are reviewed.

OVERVIEW

Students read a poem and create their own verses based on concepts presented throughout the unit.

SCIENCE & MATH SKILLS

Modeling, problem solving and applying prior knowledge to new situations

TIME

Preparation: 5 minutes
Class: 45 minutes

MATERIALS

- Overhead or copies of "Senses! Oh, Senses!" on page 38

BRAINLINK BACKGROUND (for the teacher)

The basic concepts covered in this unit follow.

- *What are senses?* Senses are our "windows to the world." It is through our senses that our brains obtain information about what is going on inside and outside our bodies.
- *Why do we have senses?* Senses evolved to take in the information needed for survival.
- *How do senses work?* External information is gathered by specialized receptors in the sense organs. Signals are then translated into a language that the entire nervous system understands, and relayed to the brain via sensory neurons. Specialized parts of the cerebrum receive the signals. Other areas process, integrate and interpret the sensory signals.

LINKS

This activity may be taught along with the following components of the Sensory Signals unit:

The Cookie Crumbles chapters:
  A Sensational Ending
  The Sensible Solution
  Review science boxes throughout storybook
Explorations:
  Gray Matters (page 2)
  Decade of the Brain (page 4)

SET-UP

The poem "Senses, Oh, Senses!" has been written by the BrainLink creators (with inspiration from Jack Prelutsky's poem "Homework, Oh, Homework!" in his book, *The New Kid on the Block*). Many of the concepts that were taught in this series of activities on sensory systems are included in the poem.

Students may add to the verses on the following page or create their own poems. Each student's poetry may be added to his/her portfolio of activities as an assessment measure.

Senses, Oh Senses

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PROCEDURE

1. Review the major concepts to which students were exposed in this unit as outlined in BRAINLINK BACKGROUND.
2. There are several options for this activity.
   - Distribute the entire poem to the students and then ask them to create their own verses, or
   - After reading the poem, let students write their own sensory poems, or
   - Read a few of the verses to get them started, and then suggest that they write verses of their own, or
   - Share the first few lines of each verse and have the students complete them with their own inspirations, or
   - Devise your own way to inspire the students to "Use Your Brains, Create Refrains."

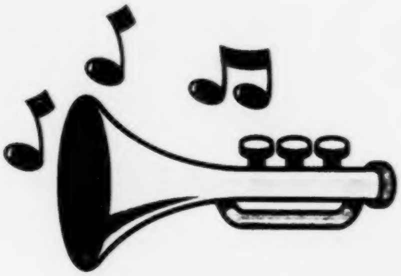
BRAIN JOGGING

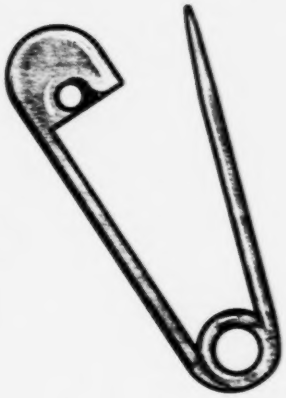
Here is another idea for you and your students to explore.

Can you imagine a sense that you don't have that you think would be fun to have? Describe how you could use it. Design a sensory receptor for it, and show where it would be. Describe how that sensory information would get to your brain, and where in your brain it would go.

Senses, Oh Senses

Senses! Oh, Senses!
I need you. You're great.
Without you I couldn't
taste what I ate,
or hear the homework
my teachers assign.
Senses! Oh Senses!
You're truly divine.





Smelling's a sense
that all of us use.
Specialized neurons
give brains all the cues
to odors that smell good
and those that do not,
so we eat what smells yummy
and throw out the rot.

Thanks to those neurons
that signal my brain,
it's easy to tell
when I am in pain.
My fingertips have
such a keen sense of touch,
I can feel and not fumble.
I like that so much!

I think that my eyes
give the best clues of all.
They show me what's out there
so I will not fall
right into a hole
or trip over a log,
or miss reading the comics
or seeing my dog.

Senses! Oh, senses!
Oh, what would I do
without you to guide me?
I'd have not a clue
to what's going on
in the world all about.
My brain would be empty.
I'd really miss out!

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Glossary

auditory canal - part of the ear that leads from the outside of the head to the eardrum

auditory cortex - part of the cerebral cortex that receives information from the ears

axon - tail-like branch of a neuron along which messages are transported in the nervous system

blind spot - place in the back of the eye that contains no receptor cells and is the exit point for the optic nerve to the brain

brain - the control center of the nervous system, located within the skull and attached to the spinal cord; the command center of the body

central nervous system - the part of the nervous system in vertebrates that consists of the brain and spinal cord

cerebellum - part of the brain located directly above the brainstem that controls the sense of balance and helps the muscles work together for learning and coordination of rote movements

cerebral cortex - the outermost component of the brain's cerebrum; controls our most advanced abilities, such as speech and reasoning

cerebrum - the large rounded outer layer of the brain where thinking and learning occur, sensory input is received and voluntary movement begins

cochlea - coiled structure of the inner ear, which is filled with tiny hairs that convert information received as sound waves by the eardrum into impulses that are sent along sensory neurons to hearing centers in the brain

cornea - clear membrane covering the front of the eye

decibel - a unit for measuring intensity, or loudness, of sound

dendrite- one of many tree-like branches extending from the body of a neuron on which signals are received

ear canal - part of the ear that leads from the outside of the head to the eardrum

eardrum - a thin membrane, stretched tight inside the ear, which helps transmit sound waves to the inner part of the ear

inner ear - the inside part of the ear that functions in balance and in converting pressure waves originating as sound into nervous system signals

integration - putting or bringing parts together to make a whole

iris - colored portion of the front of the eye; surrounds the pupil

lens - part of the eye that focuses light on the retina; any clear object with at least one curved surface that focuses light

middle ear - a small cavity between the eardrum and the inner ear where three small bones pass sound waves along to inner ear

motor cortex - the region of the cerebrum responsible for starting and controlling voluntary movement, located in a narrow strip across the top of the brain

motor neuron - a type of nervous system cell, originating in the brain or spinal cord, that conducts signals to muscles, resulting in movement

multiple sclerosis - nervous system disease in which the myelin sheath covering nerve fibers is broken down—results in a gradual weakening of the muscles

nanometer - unit of measurement equivalent to one billionth of a meter

nerve cell - neuron; a cell of the nervous system that conducts a signal from one part of the body to another

nerve - a bundle of nerve fibers and associated cells

nerve ending - one of many tree-like branches extending from the body of a neuron on which signals are received; also called a dendrite

nervous system- the brain, spinal cord and network of nerves in the body

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neuroscience - a branch of science related to the study of the nervous system

olfactory cortex - part of the cortex that receives information about smell from receptors inside the nose

optic nerve - bundle of axons leading from the back of the eye to the visual cortex

pupil - opening in the front of the eye where light enters

receptive field - the area from which one sensory receptor cell receives information

receptor - a cell or group of cells that receives stimuli from inside or outside the body

retina - portion of the eye upon which light is focused; consists of specialized light-sensitive cells (rods and cones)

sensation - an awareness of stimulation of any of the senses, such as sight, smell, touch, etc.

sense - (1) a function of the body by which one is made aware of the world outside, as sight, hearing, touch, smell or taste, or of conditions inside the body, as pain or hunger; (2) a feeling or awareness; (3) to become aware of

sense organ - body part specialized to receive sensory information, such as the eye, ear, nose, tongue or skin

sensory cortex - portion of the cerebrum dedicated to receiving information from the skin senses (touch), located just to the rear of the motor cortex

sensory neuron - a type of nervous system cell that transmits impulses from a sense organ or receptor toward the central nervous system

sensory receptor - a cell or group of cells that receives sensory information from inside or outside the body

sound wave- alternating bands of high and low pressure, detected as sound, produced when an object vibrates in air (or another medium, such as water)

stimulus - an agent that influences the activity of sensory nerves

taste bud - receptor units located on the tongue that are stimulated by chemicals and are responsible for providing information about taste to the brain

tissue - many cells of the same kind, joined together to do a specific job

tympanic membrane - eardrum; thin membrane in the ear canal that transmits sound waves to the inner part of the ear

visual cortex - part of the cortex that receives information from the eyes

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Publications

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BrainLink® Activities
Developed by
Baylor College of Medicine
Houston, Texas
ISBN 1-888997-23-0

THE READING LINK

Reading activities to use with

THE COOKIE CRUMBLES

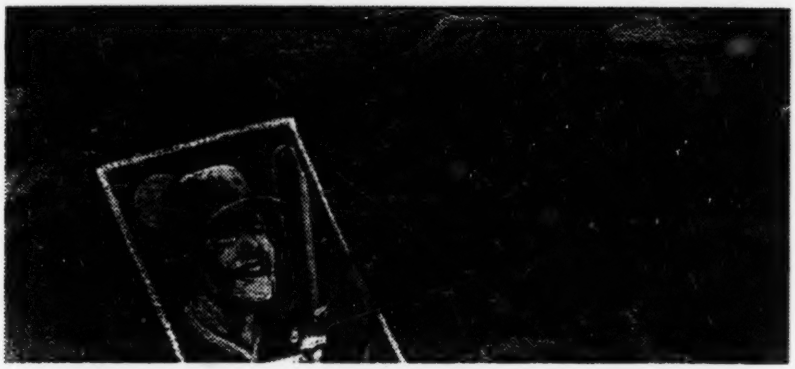
The NeuroExplorers in

A Case of Sensory Sleuthing

BrainLink® : Sensory Signals

The Reading Links have been created as ready-to-use reading and writing activities that are directly related to BrainLink adventure stories. They are not intended to represent a comprehensive reading program. The activities are related to reading objectives common to many curricula and covering a range of grade and ability levels. Teachers may wish to select from these activities those that are most appropriate for their own students.

Prepared by
Baylor College of Medicine
Houston, Texas
1997



Word Meanings

Here are some words from *The Cookie Crumbles* that have more than one meaning. Look at the meanings for each word, and then decide which meaning goes with the word in each of the sentences following. Write the number of the correct meaning next to the sentence.

roll

1. to move forward on a surface by turning over and over
2. to wrap around on itself; shape into a ball
3. a continuous, rapid beating sound
4. a list of names of the people in a group
5. a small, round piece of baked bread-dough

______To be sure that everyone was there, Shiloh called the roll.
______Isley I rolled all the way down the hill.
______This bakery doesn't make bread or rolls, only cookies.
______Lakeisha saves pieces of string and rolls them into a big ball.
______B.J.'s tapping on the table top sounded like the roll of a drum.

mint

1. a plant whose leaves often are used to flavor foods
2. a food or candy flavored with mint extract
3. a place where coins are made
4. unmarred; in perfect condition as if it were new

______ Shiloh carried a package of mints in her pocket.
______ The baseball card was in mint condition!
______ Max's mother grows mint in her garden.
______ Kyle learned that United States mints are located in Philadelphia, PA; Denver, CO; San Francisco, CA; and West Point, NY.

Here are definitions of some words used in *The Cookie Crumbles*. Write a sentence using each word as it is defined. Your sentences should tell something about the story.

1. **rehabilitation** — the process of restoring the ability to do something
2. **receptor** (sensory) — a cell or group of cells that receive stimuli from outside the body; a sense organ
3. **sense** — to become aware of
4. **analysis** — close examination; breaking information into small parts and then putting them together for better understanding
5. **vibration** — very rapid back-and-forth movement
6. **counterfeit** — to make a copy or imitation of something genuine

1. ____

____

2. ____

____

3. ____

____

4. ____

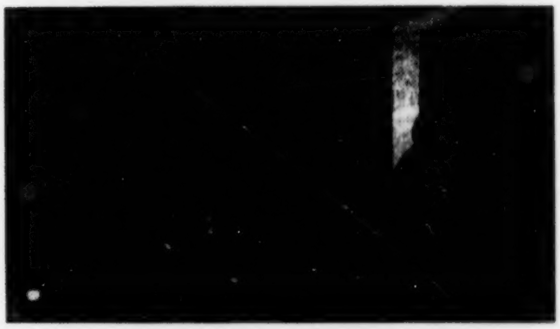
____

5. ____

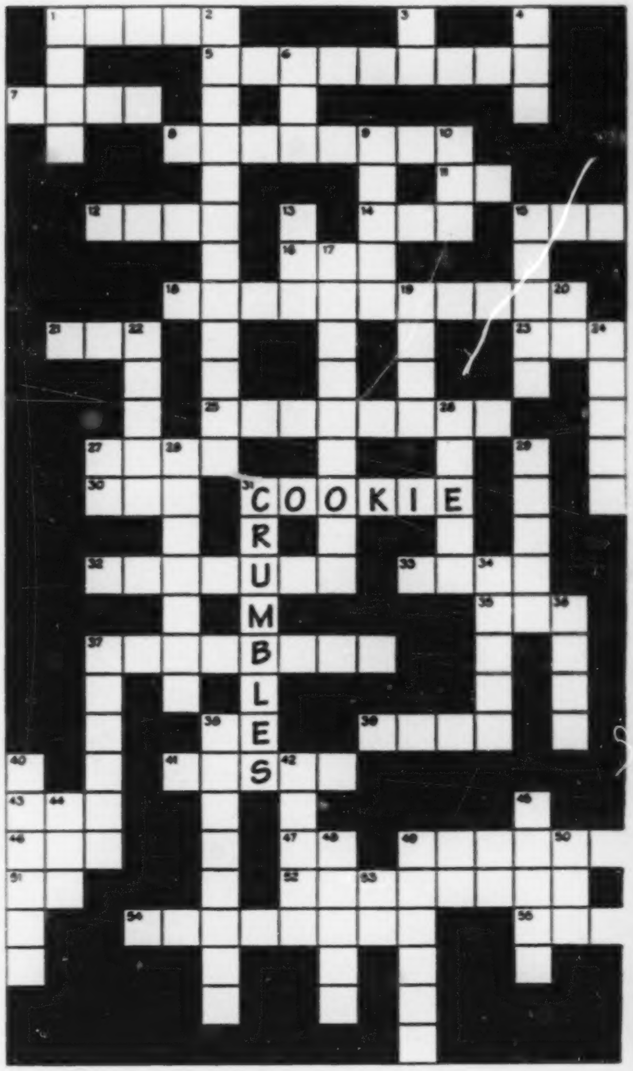
____

6. ____

____



The Cookie Crumbles Crossword Puzzle



ACROSS
1. Sensory information is put together in the ____________.
5. Shiloh is one of the Neuro-________________.
7. Body organ used in the sense of touch
8. Lakeisha's last name
11. What Kyle said when Isley I hit him in the face
12. Children (slang)
14. A sensation of extreme temperature
15. When you use your visual sense, you ________.
16. I am; you ________
18. A combination of sweet and bitter tastes
21. Good friend; buddy
23. Much; for example, a ______ of fun
25. Lakeisha played chess against her hand-held ____________.
27. Body part used in the sense of smell
30. A single thing
31. Cousin Connie's ________ Company
32. Cells of the same kind, joined for a specific job (plural)
33. NeuroExplorer who holds club meetings in his basement
35. Body organ used in the sense of sight
37. Part of the brain that is important for thinking
38. To live; exist
39. Where cookies are baked
41. The senses of smell and _______ often work together.
43. When the NeuroExplorers ________ Josh's cookies, they discovered that the taste was odd.
46. The Brain's translator
47. Consonants in the words "to go"
49. Related to the sense of sight
51. Form of *a* that is used before words beginning with a vowel
52. A word The Brain uses for the sense of hearing
54. Josh ran right into ______ legs, and was caught.
55. The color of Cousin Connie's hair

DOWN
1. Method of cooking cookies
2. Study and knowledge about the brain and nervous system
3. Either one ___ the other
4. To question
6. Comic book word for the sound of a blow or explosion
9. Connie talked on the phone to the _______ Josh Kavil.
10. When The Brain drew his diagram, he made a large ______ to show the location of each sensory organ.
13. Mickey Mantle really knew how to swing a _______!
15. Dogs have a better sense of ________ than we do.
17. Sense organs are sensory ________.
19. We can taste sweet, sour, bitter and ________.
20. In a direction toward
22. Yellow fruit that tastes sour
24. Our fingers are useful for the sense of ________.
26. Each one
27. Negative reply
28. Eyes, ears, nose, mouth and skin provide ______ input.
29. Name of the NeuroExplorer twins
31. Falls apart into little pieces
34. To gain knowledge or skill
36. To figure out where sounds are coming from, it helps to be able to hear with both ________.
37. Touch information is received in the sensory ________, across the top of the brain.
38. Sport played by Mickey Mantle
40. Josh had trouble with his right arm because of ______ on the left side of his brain.
42. When they entered the old house, they found themselves in ________ darkness.
44. A color lighter than brown
45. To move quickly
48. To show the way; lead
49. The sense of ________ is dependent upon the eyes.
50. An old-fashioned way of saying "yes" (Pirates often said it.)
53. A, B, C, ___,___

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Vocabulary Link for Super-Sleuths: Embedded Sentences

Sometimes we can figure out the meaning of new vocabulary by seeing how a word is used in the context of the story. Find these words used by The Brain in *The Cookie Crumbles*, and see if you can tell what they mean. Use a dictionary or other resource to check the definitions.

prudent, *p. 7*
endeavor, *p. 7*
illicit, *p. 30*

consensus, *p. 11*
alacrity, *p. 27*
sleuthing, *p. 34*

Now complete the following "embedded sentences," using the same words. Embedded sentences have two parts: 1) a **dependent clause** with the vocabulary word surrounded by, or embedded within, other words; and 2) an ***independent clause*** that you will create, using your knowledge of what the vocabulary word means, to make a sensible statement.

Example: **Because the 1952 baseball card was in mint condition,** *Isley I knew that it must be worth a lot of money.*

1. As soon as the NeuroExplorers had reached a **consensus** about visiting Cousin Connie's Cookie Company,

2. Although The Brain usually was **prudent** about his activities,

3. Since Max was skillful in his constant **endeavor** to translate The Brain's words,

4. When their **illicit** entry of the Cookie Company was discovered,

5. Because of Josh's **alacrity** in scooting out the open door,

6. Although each team was successful in **sleuthing** for some clues,

Main Idea

In the story, *The Cookie Crumbles*, there are nine yellow "science boxes," that provide information about the brain and nervous system (pages 3, 4, 6, 8, 17, 18, 19, 23, 26). Look at the boxes on pages 3, 4, 6 and 8. Choose the sentence in each one that states the main idea of the information in the box (1st, 2nd, last, etc.) and write it on the line below.

Page 3: The main idea is in the ________________ sentence.

Page 4: The main idea is in the ________________ sentence.

Page 6: The main idea is in the ________________ sentence.

Page 8: The main idea is in the ________________ sentence.

Summary of a Selection

Re-read the chapter called "Everyone Needs a Brain" on pages 15–16. In this chapter, the NeuroExplorers figure out a complicated plan for solving a mystery. Describe their plan in 40 words or less.

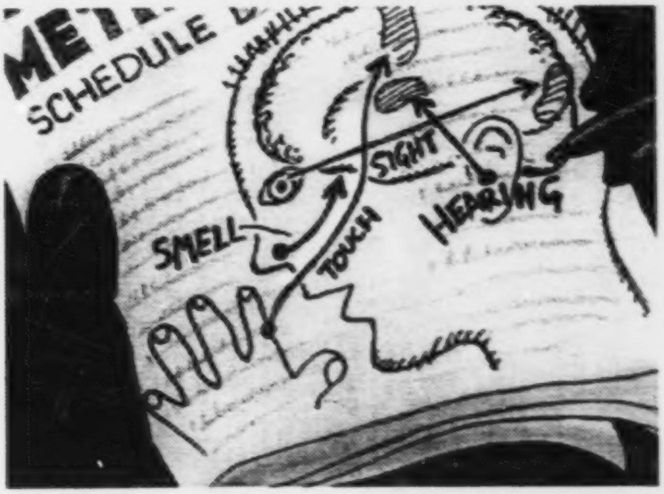
____

____

____

____

____



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Details/Supporting Ideas

Giving as many details as you can, describe the house in which Cousin Connie's Cookie Company is located

Describe the woman who opened the door.

Which senses did the Isley twins use in Cousin Connie's kitchen?

What clues did the Isleys discover about the cookies? Name as many as you can.

Recalling Sequence of Events

Read the chapters about the NeuroExplorers' search for clues on pages 17–27. Find the event below that happened last. Write 4 next to it. Then number the order (1–3) in which the other events happened.

______Lakeisha and B.J. stumbled upon paper, ink, and sheets of plastic.

______The Brain and Max found out that there's probably another Josh Kavil.

______The Isley twins discovered ink, oil and bad-tasting cookies.

______Josh and Kyle heard footsteps—it was Charlie!

After you have read the whole story, number the order in which the following events took place.

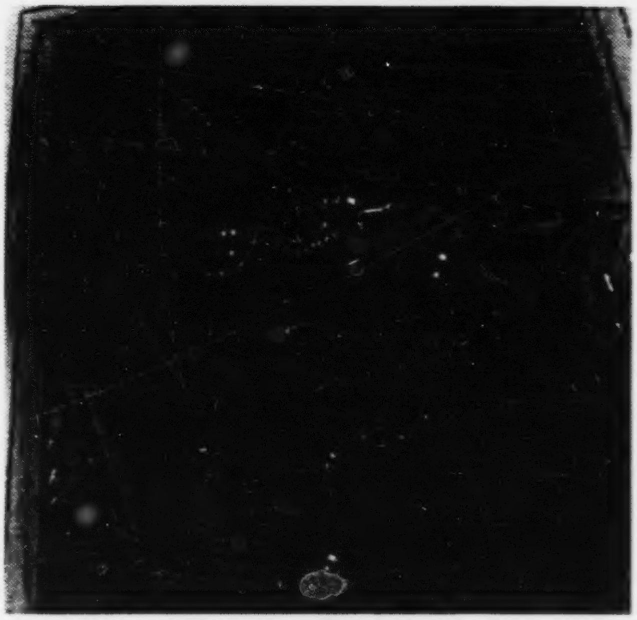
______Shiloh was grabbed while making a phone call.

______Isley I got excited about a Mickey Mantle rookie baseball card.

______The NeuroExplorers explained that they had used their senses to find clues, and that Shiloh's brain had put them all together.

______Josh brought cookies to his first NeuroExplorers Club meeting.

______The NeuroExplorers hurried to get out of a thunderstorm.



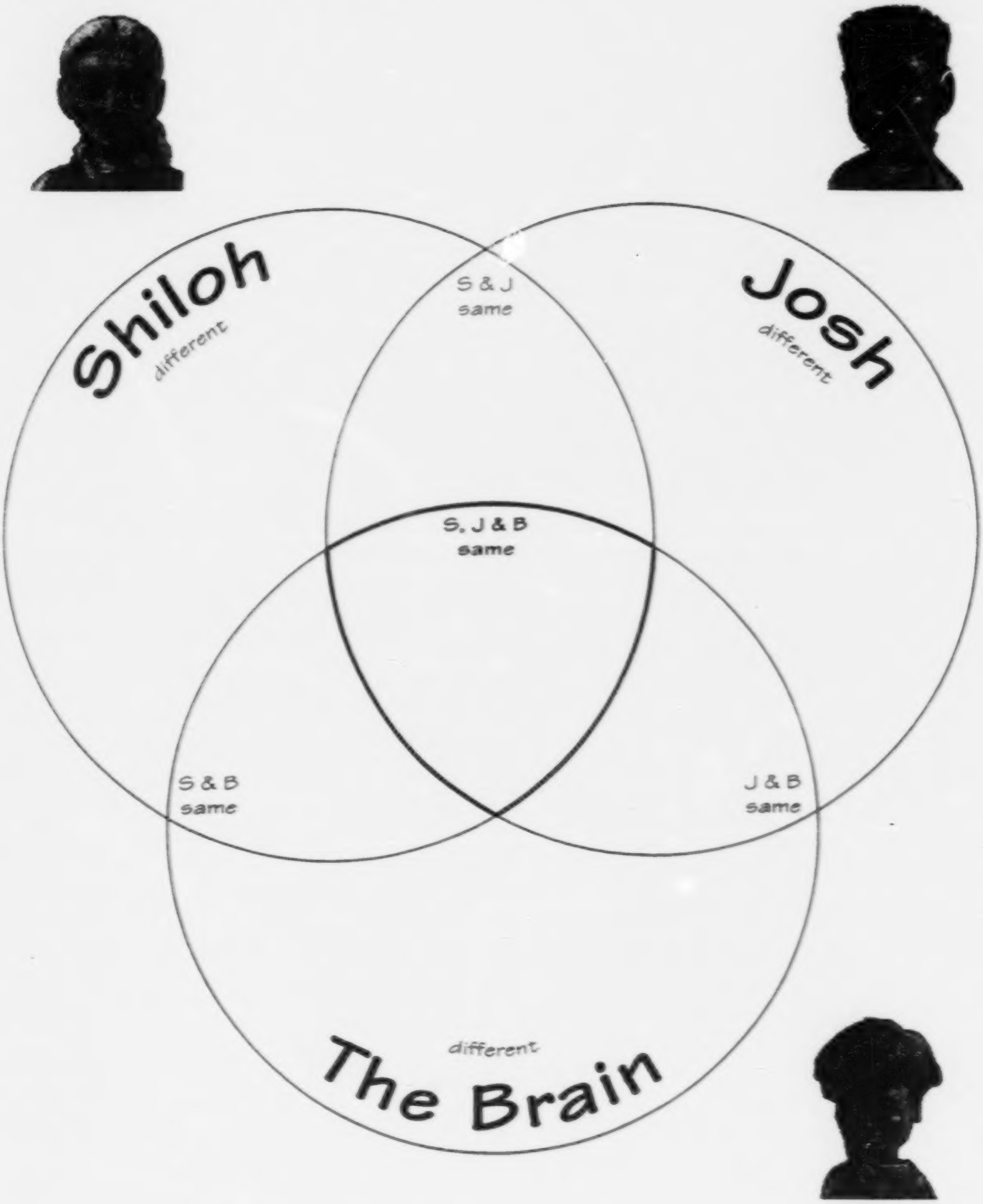
Cause and Effect

When the NeuroExplorers approached the large woman to ask if her company could make them some brain-shaped cookies, what was the result? What effect did that have on them?

Why did a baseball card in a box of cookies arouse suspicion? What did the NeuroExplorers do as a result, and what was the ultimate effect of their actions?

Comparing and Contrasting

Compare Shiloh, Josh, and The Brain. Write some of their characteristics in the circles. Write characteristics shared by two or all three of them in the sections that overlap. Are they more alike or more different from each other?


Shiloh
different
S & J
same
Josh
different
S, J & B
same
S & B
same
J & B
same
different
The Brain

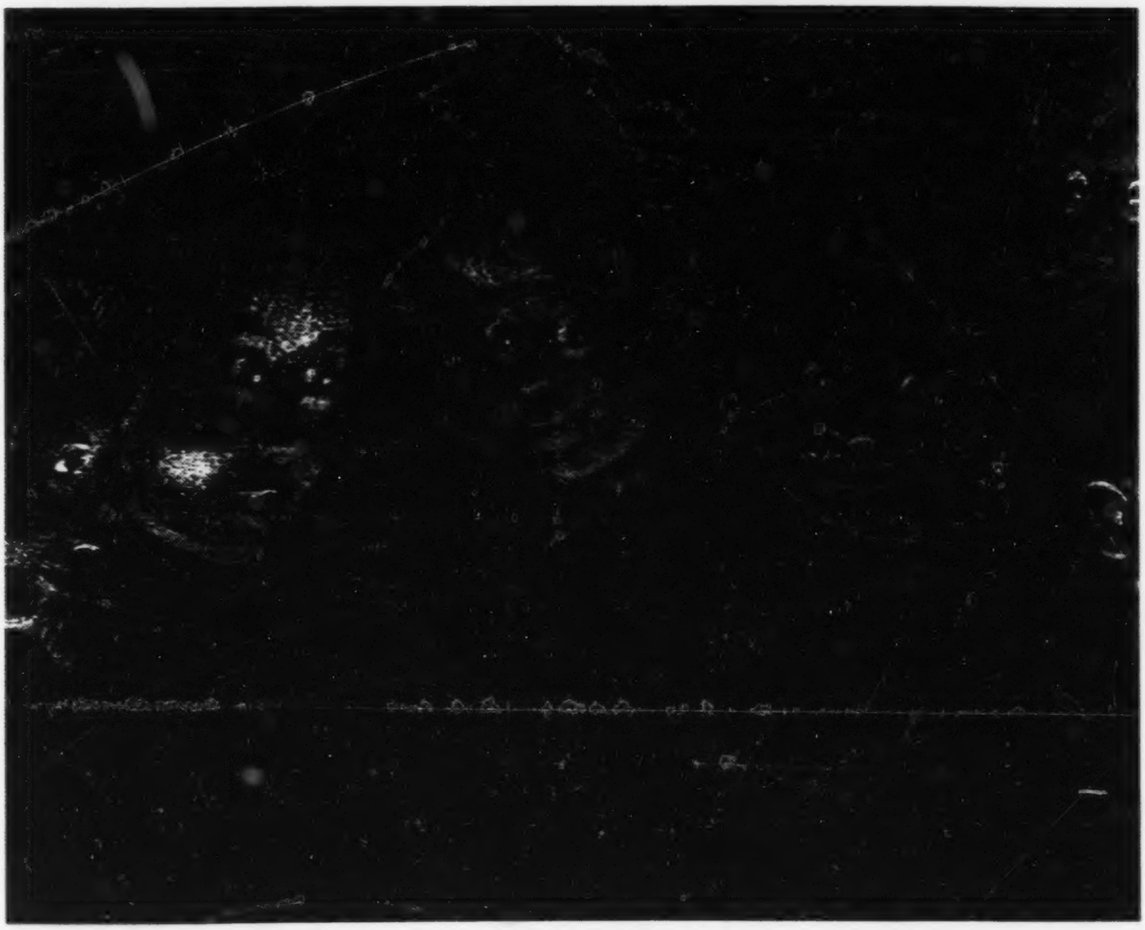
Inference/Generalization/Drawing Conclusions

What inferences might be made when a 1952 baseball card looks and smells like new? List as many different possibilities as you can.

What was the weather like when the NeuroExplorers arrived at the Cookie Company? How might it have affected their moods? Their feelings? Their reasoning? Their senses?

Re-read "Dark Voices" on pages 12 and 13. Which of the following conclusions can be reached with the information given on those pages? Fill in the circle by each statement that you think is correct.

- ○ The Isley twins are frightened in the darkness.
- ○ Connie hates kids.
- ○ Connie and Charlie are running a mail-order business.
- ○ In order to sell more cookies, they are trying to improve their baking techniques.
- ○ They have something to hide.
- ○ The NeuroExplorers couldn't hear the conversation.
- ○ Connie and Charlie know the NeuroExplorers are in the house.



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You Be The Judge

Pretend that one of the characters from the book is on trial. This character may have committed a serious crime or may be accused of being mean, selfish, lazy, silly, etc. For instance, Isley II might be accused of "not paying attention."

Choose a character, fill in his or her "crime," and write down all of the evidence you can find.

Note: Sometimes it's fun to use one of the good guys!

Name of the accused: ______________________________

Crime: ______________________________

Evidence:

1. ____
____

2. ____
____

3. ____
____

4. ____
____

VERDICT: ____________ **Guilty**

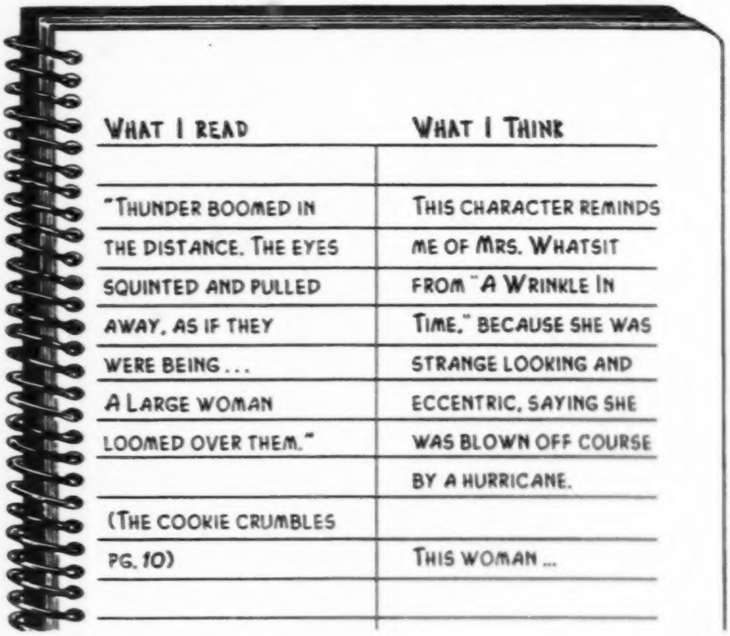
____________ **Not Guilty**

(Your signature) ______________________________

JUDGE
Master of Details, Fact-opinion,
Cause-effect, Inferences and
Conclusions

Related Writing: Thinking About What I Read

Make a Double Entry Journal: Choose a passage from this story that you find especially interesting or wonder about, or that reminds you of something else you have experienced. Copy the passage on the left side of your journal or notebook page. Then write your thoughts on the right-hand side. Journal entries can be done every day and then brought to discussion groups or shared with the whole class.



WHAT I READ	WHAT I THINK
"THUNDER BOOMED IN	THIS CHARACTER REMINDS
THE DISTANCE. THE EYES	ME OF MRS. WHATSIT
SQUINTED AND PULLED	FROM "A WRINKLE IN
AWAY, AS IF THEY	TIME," BECAUSE SHE WAS
WERE BEING ...	STRANGE LOOKING AND
A LARGE WOMAN	ECCENTRIC, SAYING SHE
LOOMED OVER THEM."	WAS BLOWN OFF COURSE
	BY A HURRICANE.
(THE COOKIE CRUMBLES	
PG. 10)	THIS WOMAN ...

Example

Other ways to begin your journal thoughts might be:

a. This character reminds me of myself because . . .

b. I wonder what this means . . .

c. This scene reminds me of a similar scene in ______________________ because . . .

d. I think this setting is important because . . .

e. I think the relationship between _________ and _________ is interesting because . . .

f. This situation reminds me of a similar situation in my own life. It happened when . . .

g. Here's what I think will happen next . . .

h. I'm confused about . . .

i. A question I would like to ask these characters right now is . . .

j. This part is realistic/unrealistic because . . .

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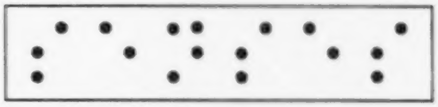
BrainLink
SENSORY SIGNALS

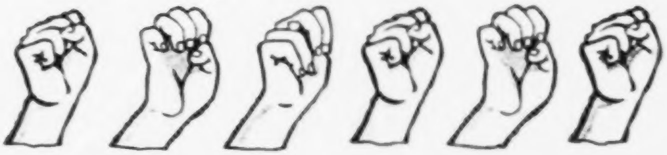
EXPLORATIONS

FOR CHILDREN AND [illegible]

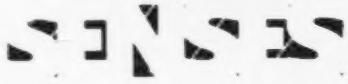
What do all of these have in common?



Turn to page 2 and push these dots through with the tip of a pen. Feel them with your fingers. Do you know what they mean?



Make these shapes with your hands. Look at them. Do you know what they mean?



**Can you see the letters?
Do you know what they mean?**

••• • —• ••• • •••

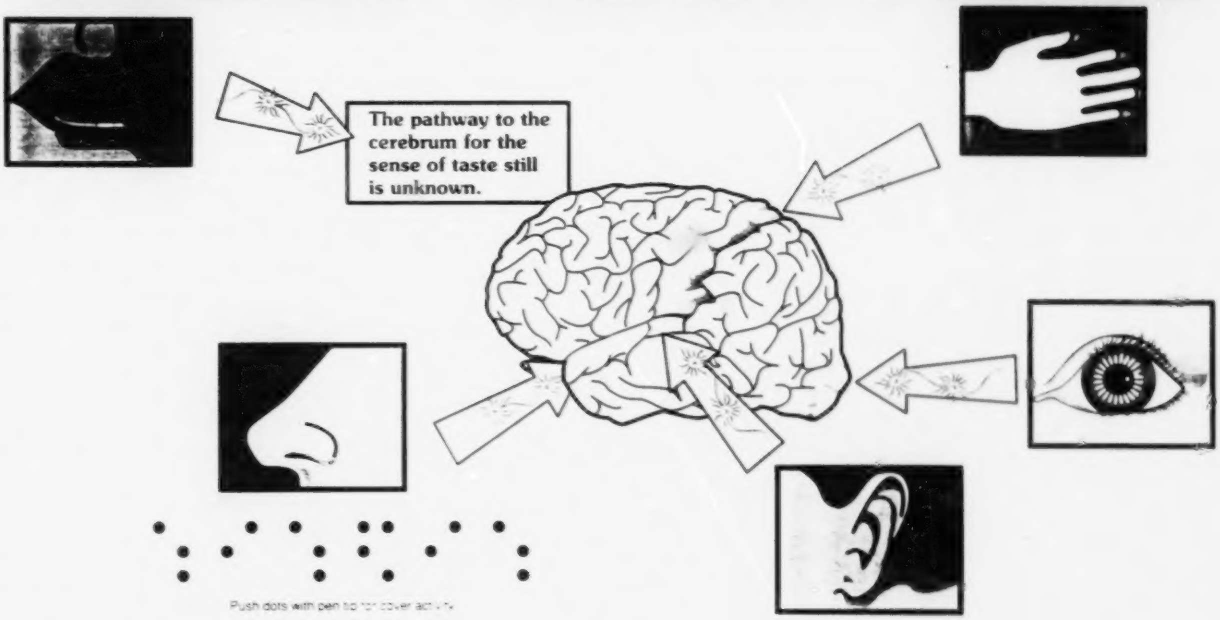
Say a short "beep" for each dot and a long "be-e-e-e-e-p" for the dash. Do you know what the sounds mean?

Read Gray Matters on page 2 to find the answers.

BRAIN FLASH

Billions of neurons, or nerve cells, work together each time we feel, smell, taste, see or hear something. Our senses are our "windows to the world."

GRAY MATTERS


The pathway to the cerebrum for the sense of taste still is unknown.

Push dots with pen tip for cover activity

Could you figure out that all the symbols on the front page are ways to communicate the word "senses"? Even though you **see** the text and the sign language, you **feel** the braille dots, and you **listen** to the morse code, your brain has the ability to decode each of the different kinds of information as the same word, *senses!*

Why do we have senses? It is our senses that let us know what is going on inside and outside our bodies. The information we get from our senses helps us to stay safe and healthy. What would it be like without senses? How hard would it be to find food or shelter or protect ourselves from danger? Even the ability to feel pain is important! Pain alerts the brain that something is wrong.

What do senses have to do with your brain? Every moment, your brain is bombarded by sensory signals. It receives messages from sensory receptors in your eyes, ears, nose, mouth, skin, and from inside your body. All the messages travel along neurons to the brain. Signals from each kind of sensory receptor go to different areas of the cerebrum.

So many messages come in to the brain all the time, it is almost as if a thousand balls of different kinds were being thrown at your brain at once! Incredibly, your brain can sort out the signals, knowing which ones to pay attention to and which to ignore. In an amazingly complex process, the brain combines information from different senses and memories of past experiences to reach conclusions and begin actions.

The senses give the brain information from inside and outside the body. They are our windows to the world!

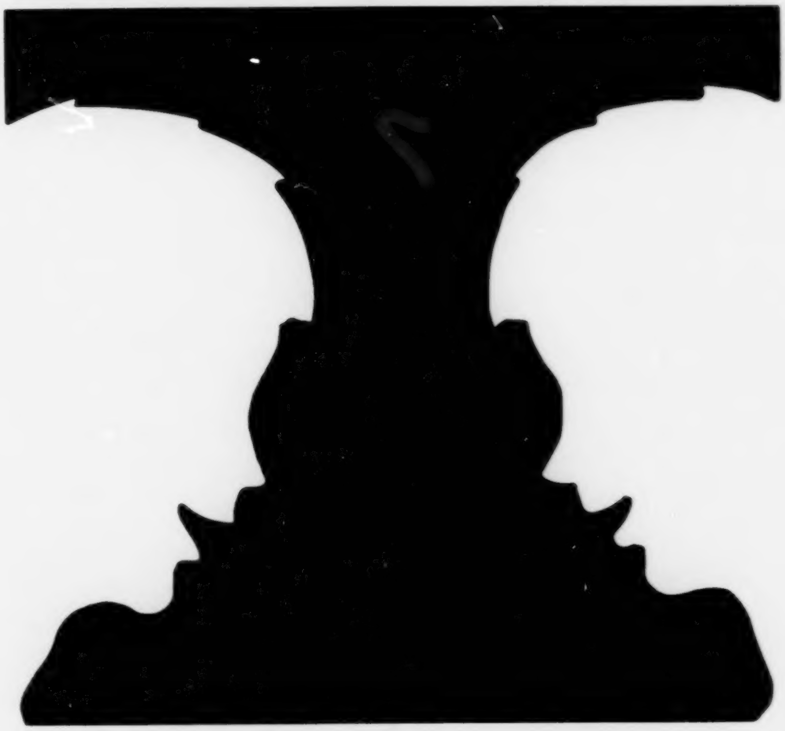
BRAIN FLASH

Believe it or not, we have other senses besides hearing, seeing, touching, tasting, and smelling. We have a sense of balance, and some scientists believe that we can sense magnetism. We also have senses inside our bodies that tell us when we are hungry or thirsty. Can you think of any other senses that we might have?

IS SEEING BELIEVING?

Most of the time the eyes and brain work together to tell us what is around us. Sometimes, though, the brain can be fooled or confused by what the eyes take in.

What do you see in the picture at right? What you see depends upon which part of the picture you look at! Do you see the twin faces or do you see a vase? You may notice that you cannot focus on both the faces and the vase at the same time. The brain is selecting part of the information available to it in order to make sense of what you are looking at! We do this all the time without being aware of it. This may be one reason why different people will describe the same scene or occurrence in very different ways.



RED BLUE
GREEN YELLOW PINK
RED BLUE GREEN
YELLOW RED ORANGE
BLUE GREEN YELLOW
BLUE PURPLE PINK
YELLOW RED ORANGE
LAVENDER BLUE
YELLOW RED BLACK
ORANGE GREEN

Read the names of the colors. Is it easy or hard? Now try saying the colors instead of reading the words. Do you find that you have to go slowly in order to get the colors right? Seeing the words, the brain expects the colors and names to match. They do not match, so the brain has to rethink and decide which information to use and which to ignore. Often we will be fooled and think we see something that is not present (or not see something that is) because of what we expect to see.

BRAIN FLASH

The human eye has 125 million receptors – *rods* and *cones* – which turn light into electrical signals.

Although we take glasses, contact lenses and hearing aids for granted now, they have been important inventions to improve our vision and hearing. Scientists still are discovering new ways to help people who have become deaf or blind by illness or accident. A tiny device called a cochlear (KOK-lee-er) implant can be placed within the inner ear by a surgeon. It directly stimulates neurons that lead from the ear to the brain, sending messages about sound. Another technology may help blind people with damage to their eyes or to the nerves connecting the eyes to the brain. This system uses a television camera that is able to send signals directly to the visual center of the brain.

Decade of the Brain logo used with permission of the National Science Foundation for Brain Research, Washington, D.C.

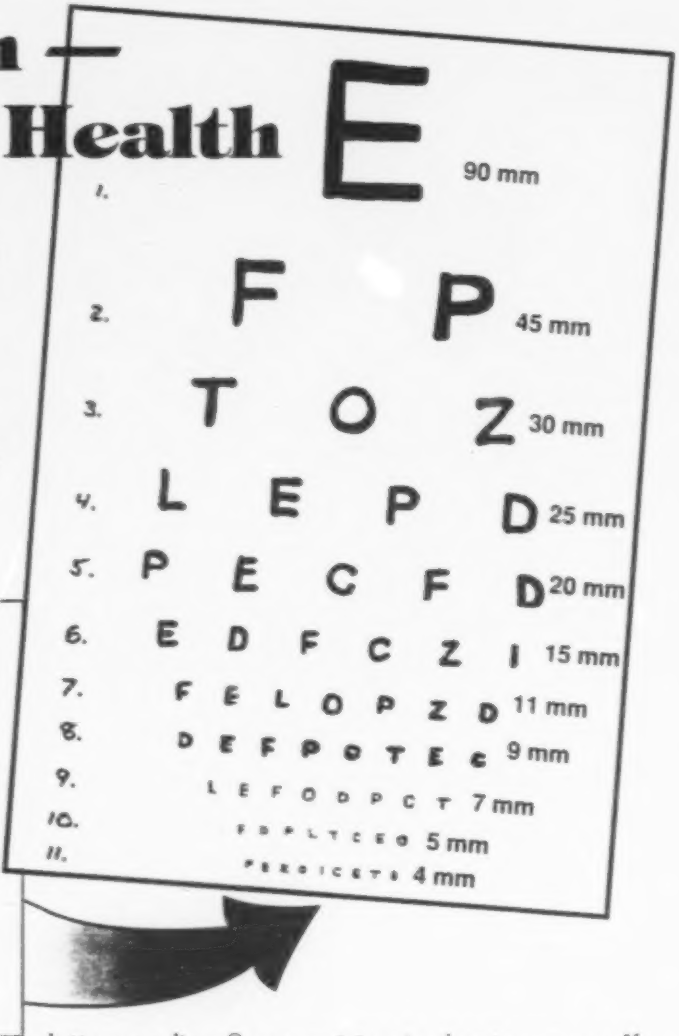
Use Your Brain — Promote Your Health

Have you ever had your eyes checked by a doctor, or by the school nurse? How many lines of letters could you read? Having your eyes checked regularly is very important for protecting one of your most important senses, your vision.

How would you like to make an eye chart to test your own vision or that of your friends and family? Here are instructions for making the chart and using it.

EYE CHART

1. Cut a sheet of poster board or paper approximately 25 cm by 75 cm.
2. Make 11 rows for letters on the chart. Draw a line for the first row 12 cm from the top of the poster board. The other 10 rows should be drawn 6 cm apart. Number each row near the edge of the chart, starting at the top.
3. Write the letters on each row in the size shown.



To use your eye chart, place it on the wall at eye level. Mark off a distance of 3 meters (10 feet) away from the chart. This is where you should stand when you use it. Cover one eye at a time and read the letters on the chart, starting at the top. Have a friend compare your answers to the letters on the chart. How did you do? Can one eye see the letters better than the other eye? If you are able to read all of the letters on line 8, your vision is about average. If you wear glasses, test your eyesight with and without them.

Now you are ready to test friends and family. As an amateur eye doctor, have you discovered any vision problems? If you think you have uncovered any, you may want to suggest a visit to the school nurse or family doctor.

7

SENSIBLE GAMES!

We often use information from just one sense to figure out what is going on around us. What happens when we use other senses to explore the world? Try these games to find out!

Focusing In!

Sit outside with your eyes open and list all the sounds you can hear. Now close your eyes. Can you hear any new sounds? Often you will find that there are softer sounds you hadn't noticed before. Why do you think it is easier to hear faint sounds if you close your eyes?

Sit in a room you are very familiar with. Put on a blindfold. Walk around the room. How well can you remember where the furniture is? Practice until you feel comfortable getting around the room. Take the blindfold off and place an unbreakable object on a table. With the blindfold on, walk around the room again and then try to find the object. How hard was it to find the object? What senses did you use as you learned to walk around the room without your sight?

BRAIN FLASH

Barn owls and bats both use sound to hunt at night. Bats hunt by making sounds and listening to the echoes made when the sound bounces off their prey. Barn owls hunt by listening to the sounds made by small animals. By turning their heads, owls can use the differences between sounds coming to their ears to find prey even in total darkness.

Who's Talking?

This is a good one to do with a few friends. Put in earplugs. Have several people talk softly or pretend to talk to you. Can you tell who really is making sounds and who is pretending? How might you be able to tell? What sense or senses could you use? Can you figure out what they are saying by watching their lips or by touching their throats?

Tasteless!

You need a piece of peeled apple, a piece of peeled, raw potato and a friend to do this one. Close your eyes and hold your nose, and have your friend place a piece of apple or potato in your mouth. Can you tell which one it is? Now, try the other one. Once the second piece is in your mouth, unplug your nose. Can you tell them apart now? How do the senses of taste and smell work together?

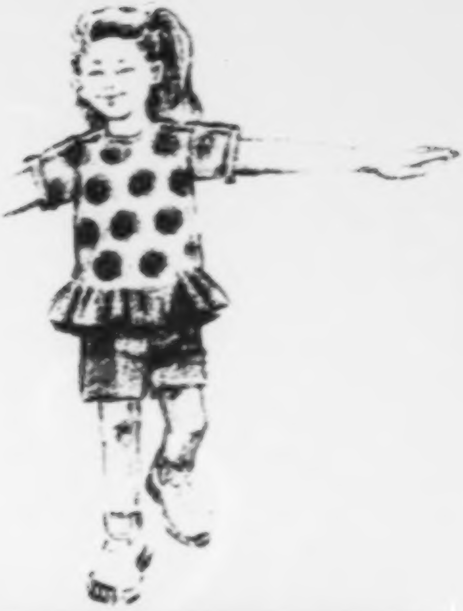
continued on next page...

SENSIBLE GAMES!

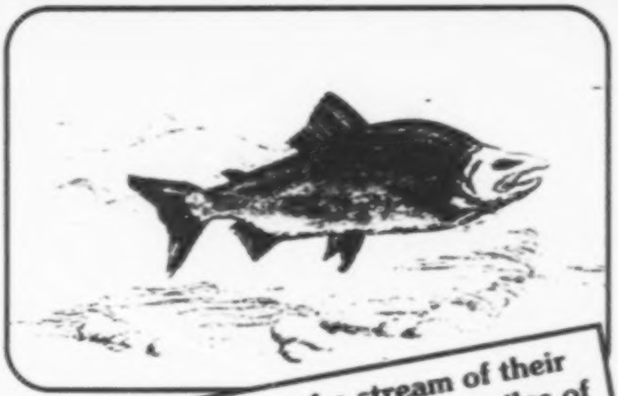
...continued from previous page

Unbalanced!

Often we use a sense without really being aware of it. Did you know that your brain uses visual information as one of the ways to help you keep your balance? Check it out yourself. Balance on one foot with your eyes open. How long could you stay up? Now try it with your eyes closed. Most people find that they wiggle around a lot more and have a much harder time balancing when their eyes are closed!



How Do They Do It?

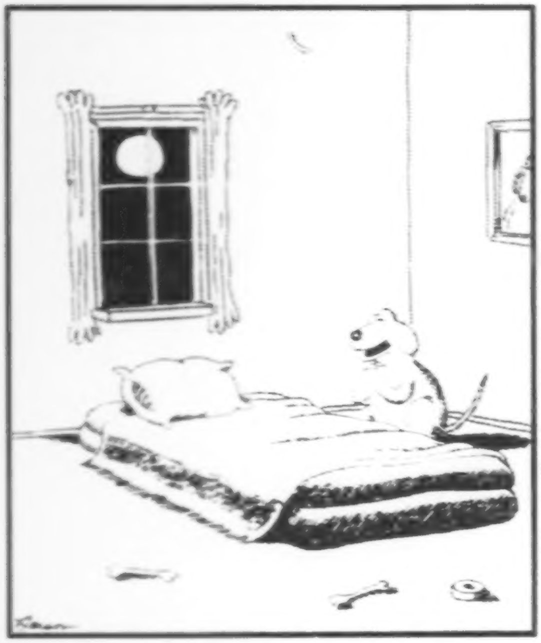


Salmon return to the stream of their birth by "tasting" their way up miles of rivers and streams until they come back to the location that tastes exactly right!

Some birds are able to sense the magnetic field of the earth, and use this information to know exactly where they are in the world!

Ants lay a scent trail that enables other ants to follow their path. The scent becomes stronger as more ants use the trail.

THE FAR SIDE By GARY LARSON



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"...And please let Mom, Dad, Rex, Ginger, Tucker, me and all the rest of the family see color."

THE NEURO SIDE

Have you ever watched a black and white movie? A dog's view of the world is just like that—shades of gray. But dogs have sharper senses than we humans do when it comes to smelling and hearing. Odors that we can't detect are easy for dogs to smell. They can sniff objects and tell which ones were touched by a particular person. Dogs can hear sounds far beyond the range of human ears.

Why do you think that humans can see color and dogs can't? What other animals see color? Why do some animals have sharper senses of smell or hearing than we do? Think about it and check it out.

Careers for Neuro-Explorers: Nurse Anesthetist

Have you or anyone you know ever had an operation? Operations would be very painful if it were not for special pain-killing medicines called anesthetics (an-is-THET-icks). Normally, pain sensors in your skin and throughout your body give your brain important signals that something is hurting you. Meet a person who is responsible for easing pain, a nurse anesthetist (uh-NES-thuh-tist).

Neuro-Explorer: Ismay Wilson, CRNA
Certified Registered Nurse Anesthetist
The Methodist Hospital
Houston, Texas

Ms. Wilson, what do you do?

I give people in the hospital who are having an operation special medication that stops the signals from their pain sensors from getting to their brains.

What do you find the most fun or most interesting about your work?

I use my nursing skills to the maximum, which I find to be satisfying. It is rewarding to know that I am helping people to feel comfortable instead of feeling pain, and I like working with lots of different kinds of people.

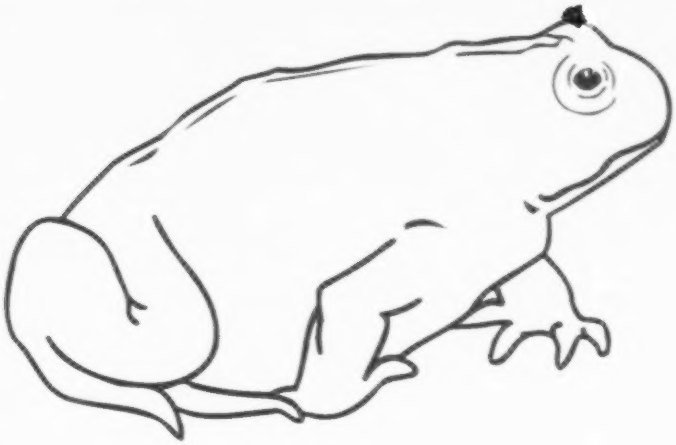
What advice do you have for future nurse anesthetists?

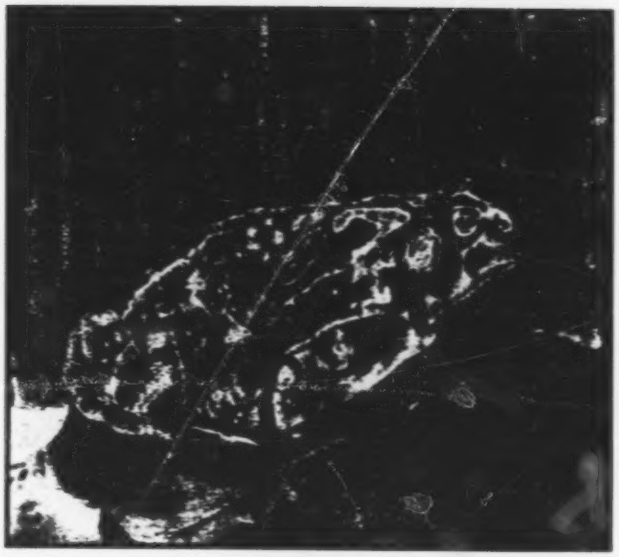
You need to set your goal to become the best possible nurse. Getting good grades in science and mathematics also helps. You also have to be very calm under pressure because you are part of a team responsible for someone's life.

Toad Hunt

Some animals avoid being eaten by tricking their predators. They are able to hide by fooling the predator's sense of vision. Many different kinds of animals use camouflage. Imagine that you are a toad in the forest. What type of protective coloration would help you most to hide from your predators? Here is a fun game to try with some friends or family members that illustrates how toads are almost able to disappear from sight.

1. Make enough copies of the toad below by tracing it onto another piece of paper.
2. Look around and decide where you are going to put your toad so that it blends into the background when colored.
3. Secretly color the toad with crayons and cut it out. When no one else is in the room, tape your toad onto a surface so it blends into the background.
4. Now, ask your partner to **hunt** for the hiding toad.





How successful was your toad at escaping the predator? Did the toad fool the **vision** of the predator with its camouflage? Can you think of any other sensory tricks that prey might use to escape being eaten by predators?

BRAIN FLASH

Did you know that boat captains used to navigate in the fog by using echoes? They would blow a short whistle and listen for the returning echo. They could estimate distances and even recognize different types of shorelines by the timing and sound of the echo that they heard back. Now blind people are trained to use the same strategy by making sounds with a cane or clicker and listening for the echoes.

BRAIN FLASH

Did you know that there is more than one kind of eye in the animal kingdom? Insects have compound eyes that make images look like a mosaic of spots–somewhat like a needlepoint picture.

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Development of Brainlink® materials was funded, in part, by the National Institutes of Health, Science Education Partnership Award grant number R25 RR09833. The opinions, findings and conclusions expressed in this publication are solely those of the authors and do not necessarily reflect the views of Baylor College of Medicine, the funding agency or the publisher.

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